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ARMY ORDNANCE

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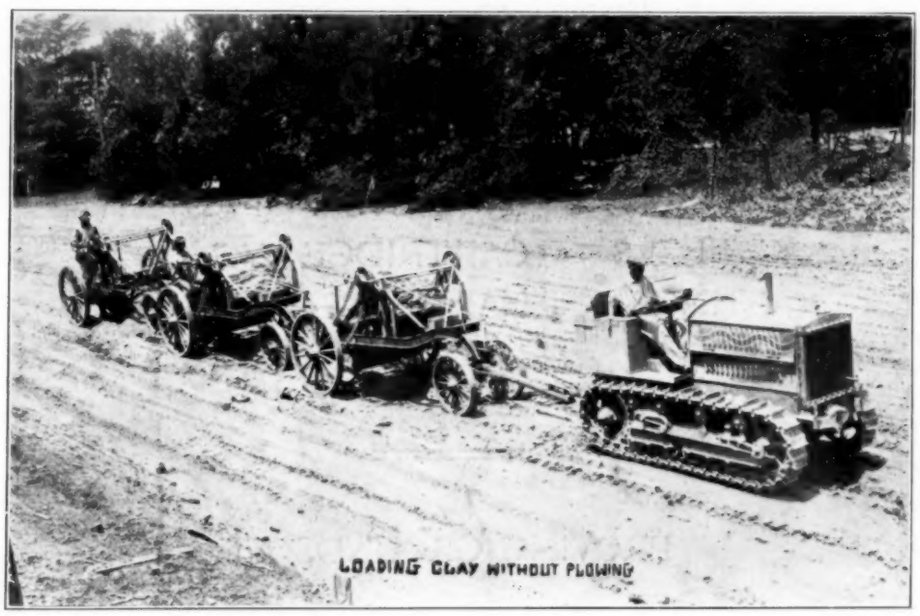

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ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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Dwight F. Davis

Assistant Secretary of War

Colonel Dwight F. Davis, of Saint Louis, Missouri, took the oath of office as Assistant Secretary of War on March 5, 1923. Secretary Davis has had a most brilliant military career, as shown by the records of the War Department:

"The records show that on September 1, 1917, Mr. Dwight F. Davis accepted a commission as captain, Company L, Fifth Missouri Infantry, having been commissioned a captain by the Governor of Missouri, and that he reported for duty at the company rendezvous, Saint Louis, on August 5, 1917, in accordance with the proclamation of the President.

"On February 27, 1918, the Commanding General 35th Division, Camp Doniphan, Oklahoma, recommended his promotion to the grade of major, National Guard, stating that, if the recommendation was approved, Major Davis would be assigned as Assistant Chief of Staff of that Division. He was promoted on March 26, 1918, to Major, National Guard, with rank from February 27, 1918, which he accepted April 10, 1918.

"Maj. Davis. was appointed a Lieutenant Colonel of Infantry, October 10, 1918, and accepted November 31, 1918. He served as Assistant Chief of Staff, G-3, 35th Division, and Assistant Chief of Staff, G-3, Second Army, American Expeditionary Forces. Colonel Davis is a graduate of the General Staff College at Langres. He served overseas from April 25, 1918, to April 20, 1919. He was honorably discharged on April 29, 1919.

DWIGHT F. DAVIS

"The Assistant Secretary was cited in General Orders No. 81, Headquarters, 35th Division, dated October 11, 1918, and in Citation Orders No. 1, General Headquarters, June 3, 1919, 'for carrying out the orders of his brigade commander in a manner utterly devoid of fear under the most intense artillery and machine-gun fire. At Baulny, on September 29 and 30, he recklessly exposed himself to the enemy fire in order to obtain information of great value to his brigade and division commanders. This citation carries the award of the silver star.

"His commanding officers gave the following general estimate of his character and ability: 'Unusually high type, morally, physically, and mentally. A superior officer in line or staff,' and 'a very intelligent, cultured, and highly educated gentleman; fine manners and address; forceful; and valuable material for line or staff, preferably in G-3 work.'"

On March 5, 1923, when the Assistant Secretary was inducted into office, the Secretary of War took the occasion to present to Colonel Davis the Distinguished Service Cross, for which honor he had been recommended by the Decorations Board. The Distinguished Service Cross citation reads as follows:

"For extraordinary heroism in action between Baulny and Chaudron Farm, France, September 29-30, 1918. After exposure to severe shelling and machine-gun fire for three days, during which time he displayed rare courage and devotion to duty, Major Davis, then Adjutant 69th Infantry Brigade, voluntarily, and in the face of intense enemy machine-gun and artillery fire, proceeded to various points in his brigade sector, assisted in reorganizing positions, and in replacing units of the brigade, this self-imposed duty necessitating continued exposure to concentrated enemy fire. On September 30, 1918, learning that a strong counter-attack had been launched by the enemy against Baulny Ridge, and was progressing successfully, he voluntarily organized such special duty men as could be found, and with them, rushed forward to reinforce the line under attack, exposing himself with such coolness and great courage that his conduct inspired the troops in this crisis and enabled them to hold on in the face of vastly superior numbers."

Thus, the new Assistant Secretary may be said to typify the best of our American manhood. An ardent sportsman and tennis champion, a valued exponent in the affairs of his native city, and a hero in battle for the cause of America, his appointment seems a most auspicious event, and one in which the Nation is especially fortunate.

The Army Ordnance Association takes this opportunity to congratulate Assistant Secretary Davis, and to extend to him every good wish for a most successful and pleasant administration of his highly important office.

ARMY ORDNANCE

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What of the Ordnance Problem?

ACCORDING to a recent news item by the Associated Press, the men who bore the brunt of the great war are rapidly passing from the stage. The article read:

"Official charts show that of more than 3,000,000 men discharged from the wartime army up to January 1, 1920, there will be available in 1925 for Class 1 service—and that means battle service, face to face with the foe—little more than 600,000 veterans.

"By 1930, a decade after their discharge in the prime of their fighting power, only 423,000 will again be ready to shoulder a musket.

"Millions trooped to the colors in the great war, but even the 18-year-old youngsters among them will be men weighted with cares and responsibilities by 1945. They will have married, or will have acquired other dependents; they will be broken with years; many will have died; some will be working at tasks as essential as soldiering, and none will be left to man the trenches. The bright day of their youth and fighting power will be but an honored heritage for their sons.

"'Of the 3,128,670 officers and men examined for discharge to December 1, 1919,' says the colorless record of the War Department, '2,931,560 were discharged without disability. It is assumed that by 1925, or approximately five years after discharge, they will have attained the status (having acquired dependents, engaged in essential occupations, incurred disabilities, etc.) of average citizens and would be available ('held for service') in the same proportions as obtained with those registered under the last draft.'

"Application of the Census Bureau death rate is the basis of War Department calculations as to probable exemptions and the basis, too, to the pressure for filling up the organized reserves with new blood each year into an unfailing reservoir of strength, at least partially ready to answer the call to arms.

"By age groups the veterans above 36 years in 1918 will have ceased to exist from a military viewpoint, in 1925, and of more than 135,000 in the 36-year class, some 20,000 might still be ready for a call. By 1930, all those above 33 years in 1918 will be gone, and by 1935 all who were above 28 years in 1918 will have vanished from the charts.

"By 1940 the youngsters who were 23 years old when 1918 brought them to the colors, will show a bare 22,000 still ready for active service, and by 1945 the 18-year-old youths of those days of war could muster probably only 5,310 veterans of St. Mihiel and the Argonne to follow the flag again."

The above analysis is applied particularly to the combatant arms, but the same logic and the same ratios apply in full measure to all branches of the service. These data and the conclusions derived from them are equally applicable to the men who were in any way connected with the design, procurement and production of Ordnance matériel during the World War. By 1945 the number of those who today are familiar with some phase of the Ordnance problem by virtue of their actual connection with it will have grown fewer and fewer. By 1955, practically speaking, those who know by experience will be no more and thus in a short span of thirty years history will repeat itself.

The Army Ordnance Association was organized and exists today for no other purpose than to prevent this very condition as far as possible. It was founded by men who realize through experience the tremendous responsibility that rests upon us as a nation to keep alive the Ordnance art and its vital importance to our national welfare.

Lest we broach a matter not within our province we will not attempt to determine the relative importance to the nation between our man-power on the one hand, and on the other our ability to promptly equip that man-power with the very latest of armament. Be this as it may, certainly the one is a direct and equal complement of the other; the one is utterly useless without the other.

The Army Ordnance Association will soon begin its fifth year of activity. Sad to say, there are some who were most enthusiastic at its beginning but who now, engrossed in the cares and pursuits of their respective walks of life, seem to have forgotten the importance of its aims and of its mission. But the Association still claims the interest of thousands who as public-spirited citizens realize the great objective to be gained. The Association, through its national medium, ARMY ORDNANCE, keeps its members informed of the latest phases of Ordnance developments and strives to present data of value from the standpoint of Ordnance engineering. Ordnance engineering literally embraces all engineering—mechanical, electrical, civil, chemical, and metallurgical. The problem of the industrial chemist is directly or indirectly, as the case may be, an Ordnance problem—and likewise the Ordnance problem is his. So it is with all the scientific pursuits of our nation—there is a correlation so intimate that it affects our own national well-being.

Today when that strange psychological reaction which is the aftermath of all great conflicts is so much in evidence, the need for an enlightened citizenry fully informed as to Industrial Preparedness, is essential. America must ever be prepared—never to start a fight—but always to prevent one. And this Industrial Preparedness is the mission of ARMY ORDNANCE.

To the members of the Army Ordnance Association is given the responsibility of helping to keep alive this knowledge, to maintain interest in latest Ordnance development, and to pass on this spirit to coming generations. This spirit, when thoroughly aroused, is one of the best guarantees that our institutions and our government will always be properly safe-guarded.

Army Ordnance

THE greater portion of the articles which have appeared in ARMY ORDNANCE in the past have come from officers of the regular service and civilian engineers in the employ of the Ordnance Department. This will perhaps, of necessity, be true in the future as in the past, but it is desirable that articles be obtained from civilian members of the Association, from officers of the Reserve Corps and, in general, from anyone who has matter of timely interest to present to our readers.

ARMY ORDNANCE is in no wise a closed forum. It belongs to *all* members of the Association and we welcome full and free discussion of every phase of industrial preparedness.

With the next issue it is proposed to inaugurate a department of "Letters to the Editor," in which will be printed whatever of good-natured and constructive criticism our membership may care to submit in this form.

The Association

THE Army Ordnance Association consists of patriotic citizens who are trying to carry forward the knowledge and experience gained in the last war to the end that the chances of another war may be minimized or if, unhappily, another war comes, that the United States shall play the preponderating part to which its citizenry and its natural resources entitle it. The objects sought to be obtained can be secured in complete measure only by a wider extention of its field and of its membership. We particularly bespeak a wider support from:

The manufacturer and industrial executive upon whom will fall the burden of munitions production in time of war;
Officers of the Reserve Corps;
The engineering fraternity—chemical, metallurgical, civil, mechanical, and electrical.

There are two ways in which the support can easily be secured:

Let each member of the Association take upon himself the duty of securing *at least one additional member* of the Association each year; and,

By the formation of active local posts wherever a sufficient number of members are located to warrant such action.

Who's Who in this Issue

THE former Assistant Secretary of War, Colonel J. Mayhew Wainwright, author of the article on "MASS PROCUREMENT," needs no introduction to the readers of ARMY ORDNANCE. His previous contributions to these pages on Industrial Preparedness have shown him to be a worthy protagonist of that most vital question.

Colonel J. K. Crain, author of "TENDENCIES IN AMMUNITION DESIGN," is chief of the Ammunition Division, Office of the Chief of Ordnance. Colonel Crain served as Ordnance Officer of the Second Army and later of the Third Army, American Expeditionary Forces, and as Chief Ordnance Officer of the American Forces in Germany. As Chief of the Ammunition Division he is responsible to the Chief of Ordnance for the design and manufacture of all artillery ammunition and components.

Dr. C. G. Storm, author of the article on "SYMPATHETIC DETONATION," is one of the recognized explosive experts of the country. He is the Chief of the Explosives Section, of the Ammunition Division, Ordnance Office, and much of the progress in explosive manufacture is due to his research and investigation. Dr. Storm served as a Lieutenant Colonel of Ordnance during the war, and was, for many years, an explosive engineer in the Bureau of Mines.

Arthur Adelman, whose article on "CARTON LOADING" will, no doubt, be of much interest to the "ammunition fraternity," and to all those interested in Ordnance development, is an Ordnance Engineer on the Technical Staff of the Ordnance Department. He is one of the best informed experts on ammunition design and his contributions to the progress of the art are many.

Colonel J. H. Burns has written a most timely analysis of "THE IMPORTANCE OF THE CHEMICAL INDUSTRY TO ORDNANCE," a topic on which few, if any, are better qualified to speak than he. Colonel Burns was former chief of the Nitrate Division of the Ordnance Department, and, as such, was in charge of the United States Nitrate Plants. His testimony before the Congressional committees and his broad concept of the entire "Ordnance Problem" have placed him in the front ranks of our practical military experts. Colonel Burns also served as Chief of the Ammunition Division of the Ordnance Office. He is now Ordnance Officer, Ninth Corps Area, San Francisco, Cal.

The article on "DYES AND THE NATIONAL DEFENSE," by Charles K. Weston, is an excellent complement from a manufacturer's viewpoint to what Colonel Burns has written from the military aspect. Mr. Weston, of E. I. du Pont de Nemours and Company, is well equipped to discuss this subject, since the company whom he represents is not only a great peacetime organization, but also because to that company is due, in no small measure, some of the truly marvelous accomplishments in the explosives industry during the World War.

Fred Olsen, author of the article on "TETRYL AND OTHER BOOSTER CHARGES," is an explosives chemist on the research staff of Picatinny Arsenal. He has had broad experience in the manufacture of explosives and his work in connection with booster compositions is regarded as far-reaching.

M. Georges Claude, the eminent French chemist, is the author of the article on "THE SYNTHESIS OF AMMONIA," which was given as a lecture before the Societe des Inginieurs de France during May, 1922. The translation from the French is the work of Mr. F. E. Smith of the Fixed Nitrogen Research Laboratory, Washington, D. C. In view of the great interest in the subject of nitrogen fixation today, it is felt that this discussion will be a very interesting and important contribution, not only to the forum reached by ARMY ORDNANCE, but also to the general literature on the subject.

Dr. Tenny L. Davis, Professor of Organic Chemistry at Massachusetts Institute of Technology, has written the very interesting article on "ROGER BACON'S GUNPOWDER." Dr. Davis served as an officer in the Ordnance Department during the war and made valuable investigations into the use and manufacture of explosives. He is at present engaged, in connection with his other duties, in explosive research for the Ordnance Department at Boston Tech.

Lieutenant Commander Alfred G. Zimermann, U. S. N., Chief of the Metallurgical and Testing Division of the United States Naval Gun Factory, is the author of the article on "GUN RECOIL AND RECOIL SYSTEMS." Commander Zimermann made special studies in metallography and metallurgy at Harvard, and served as Chief of the Metallurgical and Testing Division of the U. S. Naval Gun Factory from 1918 to 1920.

Miss M. B. Morris

THE Army Ordnance Association announces the resignation of Mrs. C. C. Shepard, better known to the readers of ARMY ORDNANCE as Miss M. B. Morris, who has been Associate Editor of ARMY ORDNANCE since its beginning.

No small measure of the success of the magazine has been due to her untiring efforts and to her literary ability. We regret to lose one who has been so intimately associated with the magazine, and on behalf of the Association we extend to her our sincere good wishes.

Mass Procurement

By

COL. J. MAYHEW WAINWRIGHT
Member of Congress, Former Assistant Secretary of War

AN understanding of the fundamentals of wartime procurement is essential for everyone who is to be in any way connected with the supply of our troops in the event of an emergency. It is to be borne in mind that the rate of mobilization is a direct function of the procurement of essential commodities. It should be clear in the mind of every one that we can mobilize men and train them faster than certain items necessary for their fighting efficiency can be manufactured and delivered to them. As commanders in the field, it should be the duty of every officer to take as much pride in limiting waste as he takes in having a well-disciplined command. As you all know, waste is an indication of poor discipline. In wasting supplies, which an over-generous government furnishes to our troops in time of war, it is not only adding to the difficulty of defeating the enemy by increasing the difficulty of supply, but it is a violation of a duty which we owe the people not to waste unnecessarily public funds. In addition, commanders in the field, while keeping their minds open to developments in warfare should be conservative in recommending changes in types of matériel merely for the sake of change. It will frequently take more than a year to reach production in many changes of type, and in the meantime troops must of necessity get along with matériel which had theretofore been approved by the General Staff as sufficient for the emergency.

The Honorable J. Mayhew Wainwright
Former Assistant Secretary of War

ARMY ORDNANCE is privileged to publish this article on "Mass Procurement," from the former Assistant Secretary of War, the Honorable J. Mayhew Wainwright. On March 3, 1923, Mr. Wainwright resigned as Assistant Secretary to become a Member of Congress from the 25th District of the State of New York, to which honor he was elected in the fall of last year.

As Assistant Secretary of War, Colonel Wainwright has been particularly responsible for all matters affecting Industrial Preparedness, and the great energy and executive ability which he has brought to this problem have resulted in the establishment for the first time in our Nation's history of adequate peace-time plans to meet our war-time industrial needs.

To Congressman Wainwright the Army Ordnance Association extends its sincere good wishes, being confident that in the halls of national legislation his power and ability will be as fruitful for our Country as were his services as Assistant Secretary of War.

Necessity for Planning.

We are all familiar with Washington's advice regarding preparing for war in time of peace. Military men are apt to think that his remarks were addressed to civilians. As a matter of fact, military men are the only ones whose ministerial duty it is to plan in time of peace for war. This responsibility rests in direct proportion to an officer's relation to the military establishment. Professional soldiers devoting their whole time to the Government interest must assume first responsibility for planning. Officers of the National Guard and officers of the Reserve Corps must also share in this responsibility, because they have voluntarily assumed a responsibility to their Government greater than that of other citizens. Every principle of self-interest urges us to plan every possible phase of war in time of peace. Prior to the World War industrial planning was not given serious consideration either in our service or the armies abroad. Our own situation in this respect is too well known for me to weary you with repeating, but I call your attention to a statement made in a recent book, "Hugo Stinnes," by a German author in which he remarks as follows regarding plans of the German General Staff:

"We must also remember that though there was an accurate plan for general military service, not even the most primitive arrangements for general industrial service in war times had been prepared."

Germany was able to recover from her initial over-confidence because of a system of vertical trusts built up by men like Stinnes, Thyssen, and others. Vertical trusts, owning as they do their own raw materials and controlling within themselves all the economic processes until finished products are delivered to markets, are valuable assets in war.

Attention is called to the fact that between April, 1917, and November, 1918, we had four different chiefs of staff and in the procurement branches several general officers were relieved. It is no reflection upon these officers to state these facts. In all probability we shall not enter another war with any abler officers in their respective positions. Mr. Root said regarding his predecessor who had been driven from office as a result of public criticism of the management of the war with Spain, that no man could have made a success of the job. Similarly, it is quite improbable that any officers however able could have brought order out of chaos in the first year of our industrial situation of the World War, for the simple reason that nothing regarding the industrial phase of preparedness had been prepared in time of peace, and no one can plan a war and fight it at the same time without tremendous loss in men and money. The evil ef-

fects of a failure to plan for industrial preparedness are not alone evidenced by the fifteen billion dollars of money spent in the war, but they rise up to plague every citizen at the present time in the matter of taxation and high cost of living. During the war of 1812 wholesale commodity prices rose from an index figure of 175 to 250, or 43 per cent. During the Civil War they rose from 100 to 180, or 80 per cent. During the World War they rose from 100 to 240, or 140 per cent. The result is that the purchasing price of a dollar at the present time compared to 1913 is approximately 64 cents. Not only was there no comprehensive plan for industrial preparedness in existence at the time we entered the World War, but after we entered the war there were delivered to the procurement branches between September, 1917, and September, 1918, not less than six different strength or mobilization plans. When I tell you that it has taken fifty officers nine months merely to figure the requirements of the War Department for the mobilization plan at present adopted by the General Staff, you will readily see how impossible the lack of definite information regarding mobilization made the task of the branches in the matter of procurement. The result of such instability was very naturally a tremendous over-buying. Each responsible officer and dollar-a-year man was afraid to under-estimate the situation; so after making as close an estimate as he could from data furnished him he would take a liberal factor of safety in order that he would not be accused of falling down on the job. As an example, under the present mobilization plan the Quartermaster Corps has figured that the cost of all harness, pack and saddle equipment, which practically includes all the leather requirements of the Army, will cost at current prices approximately sixty million dollars. During the World War for lack of plans there was spent for these same items three hundred million dollars. Had the officer who has worked out the requirements on this comparatively minor item been furnished the same data before the World War, he could have saved the Government two hundred and forty million dollars. It is fully realized that the procurement branches were working under great handicaps during the war, and even in their planning before the war; these facts are mentioned not by way of criticizing anyone, but merely that we may keep our minds open to the truth regarding the lessons of the World War.

Industry cannot win a war—soldiers and sailors must do that; but industry can lose a war by a failure in time of peace on the part of the Government to make adequate plans for industrial mobilization. Just as a commander in the field may be restricted by a failure in supplies, the larger plans of the War Department may have to be modified by the quantity of supplies which can be procured in a given time.

Procurement Plans Must Be Revised.

War plans of course must be revised. Our present procurement plans are based upon a maximum effort as laid down by the General Staff. Procurement plans depend primarily upon the mobilization rate. We have only approximately finished the military phase of procurement plans under the present mobilization scheme. It will take about five years to work out procurement plans under this scheme. You will see, therefore, the vital necessity for keeping the present estimate of mobilization rate stabilized for that length of time. This, of course, does not interfere with the revision of special plans of campaign, etc., but it is absolutely necessary that the procurement branches be given time to complete their war procurement plan. Thereafter, it can be revised annually without serious difficulty. The reason why this length of time is required is that branches like the Ordnance Department and Air Service make demands on industry for which no facilities exist, and it will require an industrial survey of a vast number of factories before they can accurately estimate war-time production. These branches must not only survey these facilities but they must go carefully into the field of secondary requirements, such as machine tools, jigs, dies, gauges, etc. With the number of officers available and especially with the limited funds available for visiting facilities, this preliminary survey will take a long time. Breaking ground and laying a foundation is always a slow and tedious task, but if well done, the other elements fall quickly into line and the superstructure can be quickly and easily altered.

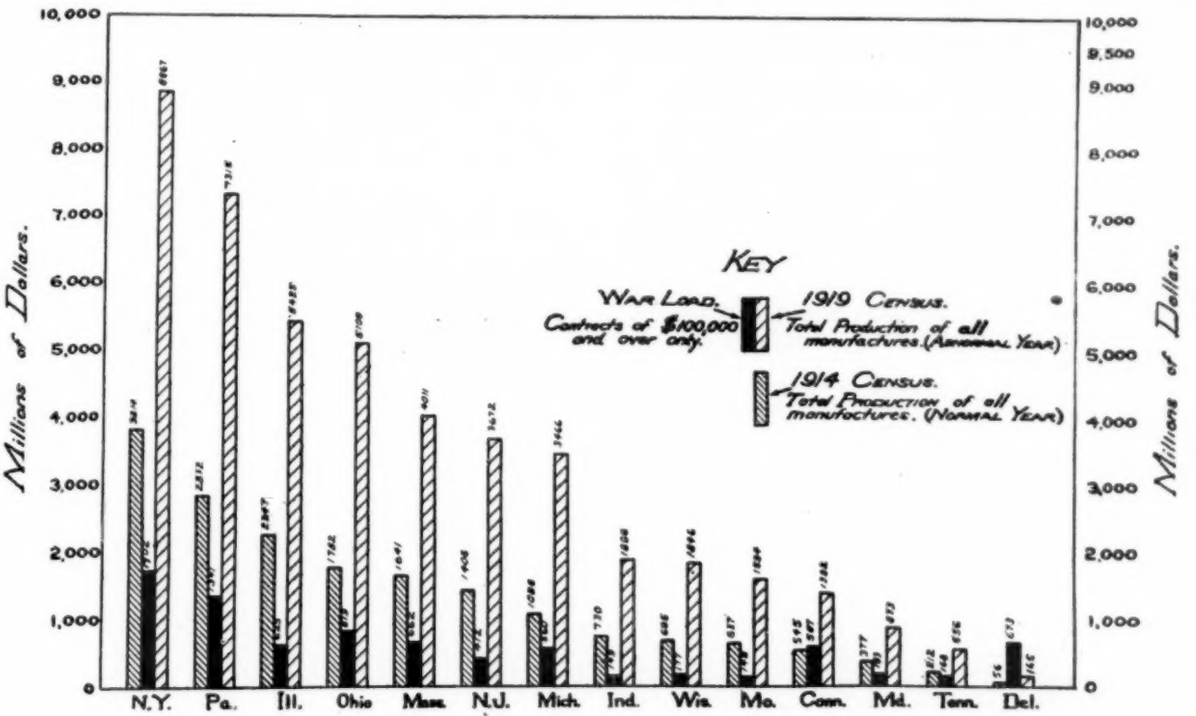
Duties of The Assistant Secretary of War.

The duties of the Assistant Secretary of War are prescribed in Section 5A of the National Defense Act, as amended June 4, 1920. Under this law he has two distinct functions: First, he is responsible for supervising the procurement of all military supplies and other duties relating thereto; second, he is required to see that adequate provision is made for the mobilization of material and industrial organizations. The statute says he shall be charged with "the assurance of adequate provision" for industrial mobilization, but this, I think, must be taken to mean that he is responsible that adequate *plans* are made. War, of course, consists primarily of two elements—personnel and matériel. With the Assistant Secretary of War there is no responsibility regarding personnel. The law requires that the officers and employees of his office shall be detailed from the procurement branches. It will be noted from the language of the law that the office of the Assistant Secretary of War is not an *operating* office; that is, his duty is one of supervision and co-ordination. It is very necessary to emphasize this fact because Congress went very thoroughly into this matter and decided, in redrafting the National Defense Act, that the responsibility for procurement should rest directly upon the Chiefs of procurement branches. In order to have the advantage of the experience of the World War in preparing plans for industrial mobilization, the President, by executive order, made the Secretary of War the custodian of the records of the War Industries Board and the Council of National Defense. These records are, of course, priceless so far as planning for industrial mobilization is concerned. It will take about six months more to classify them so that they will be readily accessible for the use for which they are hereafter intended.

Organization of Office.

In time of peace, the duties required by the Assistant Secretary under Section 5A of the National Defense Act are discharged under his supervision by a Procurement Division divided into two sections, one concerned with current procurement and the other with war planning. I believe the theory and necessity for planning is fairly well established as a War

Department doctrine at the present time. I am sure that the procurement branches realize now, if they never did before, that their prime function is to prepare for war and that however letter-perfect they may be regarding peace-time procurement, if they fail the Army and the country in time of war, they have failed to justify their existence. In order to emphasize the importance of planning for war over current procurement, eight officers have been assigned to the Planning Branch, while only one assists in supervising current procurement. That is to say, the office is primarily a planning branch for industrial mobilization and as such, I might say that it has no



Comparison of War Load and Value of all Manufactures, 1914-1919, for the fourteen leading industrial States.

peace time *organization*, its duties being primarily to plan. The War organization of the office would take on an entirely different appearance. It is sufficient for the present purpose to state that my conception is that the Assistant Secretary will be primarily concerned with two things: First, what do we have to procure? Second, how is production coming along? In order to handle detailed questions as they arise the office would probably be divided into an administrative division, a purchase control division, and an industrial division. The purchase control division would deal with those matters regarding which the Secretary must exercise his functions of supervising procurement. This division would be concerned with such things as priorities, allocations, price control and contracting methods. The industrial division would be expected to handle questions relating to the industrial phase of the plans pertaining to such matters as power, labor, transportation, facilities and conservation.

Agencies Responsible for Procurement.

As a result of the confusion caused by the uncoordinated effort of the War Department branches, experiments with various kinds of new machinery for procurement during the World War were attempted. The following were either provided by law or were set up from time to time by executive order: Council of National Defense, Advisory Commission thereto; Board on Mobilization of Industries; Munitions Standards Board; Munitions Board; War Industries Board; and Purchase, Storage and Traffic Division, General Staff. All of these had, at one time or another, something to do with the procurement program. With so many control agencies attempting to function you can easily see what confusion so many new and uncoordinated agencies must have created in the matter of procuring supplies. Nothing can be accomplished when there is doubt as to whom is responsible.

As heretofore noted, existing law contemplates that the responsibility for procuring supplies for the Army rests directly upon the chiefs of procurement branches, subject only to the supervisory power of the Assistant Secretary of War. These branches fall naturally, so far as mass procurement is concerned, into three groups: Group "A," Ordnance Department, Air Service, Quartermaster Corps; Group "B," Corps of Engineers, Signal Corps, Medical Corps; Group "C," Chemical Warfare Service. I will touch shortly upon the major problems which differentiate these branches from each other. These branches must set up in Washington the necessary machinery for figuring requirements under any war program and an office organization for the purpose of exercising control over methods of procurement. In carrying on their field operations the branches must necessarily set up industrial districts corresponding to their respective needs. Industry of course divides itself along strata of commodities and an ideal organization would be to divide the country up into industrial districts along such strata of commodities. This, however, would produce so many units that their coordination would be very

difficult if not, in fact, impossible. Therefore, the country is divided by each branch into districts corresponding most nearly to its needs. The Ordnance Department, for example, has a Pittsburgh and a Cleveland district, because these are centers of metal industries; the Signal Corps districts are necessarily built up around those existing facilities, such as the General Electric Company, the Westinghouse Electric Company and the Western Electric Company, dealing in electrical equipment. The Quartermaster districts necessarily group themselves around existing depots, which, as the result of long experience, have been located nearest the commercial centers for those items procured by that branch. Similarly the Air Service will have district headquarters at such points as Buffalo and Detroit, which promise to become important aircraft centers.

This brings us to a consideration of the problem of control—shall it be military or civilian? Evidently it was the purpose in assigning the duty of supervising procurement to a civilian Assistant Secretary of War to emphasize the fact that procurement is primarily a business proposition. However, this must be accepted with some reservations. What we must do is to put military men in positions where they can interpret *what* is to be done and then rely on business and industrial experts to say *how* it shall be done. The Assistant Secretary of War, for example, will want two men constantly at his elbow: a military man to tell him what the demands will be on industry; a civilian to keep him informed as to the rate of production. Those branches dealing primarily in commercial articles, offer but little difficulty except where there is a threatened shortage; e. g., in leather or wool, when the advice of civilian experts becomes vital. On the other hand, those branches like the Ordnance and Air Service having manufacturing programs must depend primarily on civilian advice skilled in industrial production. For this reason, the chiefs of these branches are placing civilians in charge of their industrial districts with military men as executives. The Quartermaster General and the Chief of Engineers on the other hand will rely upon their existing purchasing agencies to insure their procurement program, augmented by civilian advisers and inspectors as required.

Problems of Procurement

In planning for mass procurement, it is necessary to determine:

(a) What will be required.
(b) How much will be required, (taking into consideration war reserves on hand).
(c) When and where it will be required.
(d) Ways and means of procurement; i. e.:
    1. Where it can be procured.
    2. Who will procure it.
    3. The rate of production, and
    4. The cost.

Discussing these in detail, it is the function of the General Staff to decide what will be required. It is likewise its function to fix tables of initial equipment and other allowances as well as to decide when and where the various items will be needed. Decisions regarding ways and means of procuring these supplies must be made by the Assistant Secretary of War. The cost must be estimated in order that the Treasury Department may have the necessary data on which to make plans for financing the war.

There are certain principles which must be observed in connection with mass procurement; for example:

(a) Responsibility for actual procurement of supplies rests exclusively upon chiefs of procurement branches, subject only to the supervisory power of the Assistant Secretary of War. *No one must be permitted to get between a branch chief and his mission.*

(b) Procurement Organizations must, so far as possible, be the same in time of peace as in time of war, in order that the War organization may be merely the expansion of peace-time activities.

(c) That no *supplies* shall be procured in Washington, the control of procurement only being exercised at the seat of Government. Procurement of things other than finished products may, however, have to be handled in Washington, e. g., the procurement of real estate or the handling of large construction projects may have to be centered here.

(d) That Corps Area Staff Officers are essentially operations men and must not be assigned functions in connection with *mass* procurement.

I have heretofore noted that the procurement branches naturally divide themselves into three groups so far as mass procurement is concerned. Within these groups, however, there are two general lines of demarcation. On one hand we have those branches of which the Quartermaster Corps is the chief representative, dealing in vast quantities of supplies, mostly commercial in character. On the other hand, we have the case of the Ordnance and Air Service, dealing in items which are either not produced commercially in time of peace or in such limited quantities as to have little effect upon war-time procurement. With the first class (those dealing in commercial products), the problem is merely one of stimulating production for which peace-time facilities already exist. The main thing in this connection is to see that specifications follow as closely as possible commercial standards. The problems facing the Ordnance Department and the Air Service are peculiarly critical. In the case of the Ordnance Department, the maintenance of war reserves is vital. While at the present moment we are fairly well off in this connection, ten years or even five years hence we probably will be in a very bad condition, especially in the matter of explosives. Besides, weapons of war change so rapidly that it is very difficult to forecast ten years in advance the types that will be required. It is very unlikely that Congress will ever consent to appropriate in time of peace sufficient money to maintain a war reserve which military men would like to have in order to insure a more rapid mobilization. There seems to be, therefore, but one thing to do in connection with the Ordnance problem, and that is to secure sufficient appropriations annually, to keep the art of manufacture alive. This will involve placing, annually, "educational" orders with selected facilities, furnishing them with the necessary jigs, dies, gauges, etc., in order to encourage them to experiment under a flexible form of contract which will insure them against loss. The Air Service is in an even more critical state of affairs. They are wholly dependent upon an infant industry which offers considerable hope for the future but which at the present time is in a very bad condition

due to lack of public interest in flying. There is a bill now before Congress to encourage civilian aviation and through some legislative stimulus of flying as well as the encouragement of mail service by airplane, it is hoped to encourage aircraft production so that it may furnish some foundation for expansion for war-time requirements. The following is a list of the most critical items of procurement, giving, with existing war reserves and present estimated rate of production, the time which will probably elapse before production meets requirements:

(a) In the Quartermaster Corps it will take six months to meet requirements in uniforms, hats, and leggings, as the cloth has to be manufactured and the tailoring industry must be stimulated. Shoes will take four months, as it is first necessary to obtain lasts. With wagons and harness six months will be required to expand the industries. The above are based on tables of allowances; probably there will be sufficient uniforms to clothe every man.

(b) In the Ordnance Department the most critical items will soon be small arms ammunition and artillery ammunition, since, although there are now sufficient reserves, these are deteriorating very quickly. The reserve of small arms ammunition will have become almost completely unserviceable by 1928, and that of artillery ammunition by 1933. If no new reserve is built up there will be a great shortage on mobilization. At the present estimated production rate, it will take twenty-two months to meet requirements in small arms ammunition, and twelve months in artillery ammunition. The reserve of pistols is small, and production is difficult with few facilities, so that requirements cannot be met in two years.

(c) In the Air Service it will require six months to equip the first army with aircraft and aircraft engines, and ten months to equip all Air Service organizations under the most favorable circumstances, due to lack of facilities for manufacture. Commercial and military peace requirements for aircraft are not sufficient to keep the manufacturing industry alive. This does *not* take into consideration any requirements except those of the War Department.

(d) In the Medical Department it will take nine months to meet requirements for surgical instruments due to lack of manufacturing facilities and dies. With certain exotic drugs, such as opium, strychnine, and iodine, the date of meeting requirements cannot be accurately determined, as the war reserve is small and these drugs must be imported.

(e) In the Signal Corps three months will be required to obtain the necessary production in dry batteries, as it is necessary to secure and distribute raw materials, expand facilities for manufacture, and secure additional labor. Radio equipment will require twelve and one-half months, due to lack of facilities, high obsolescence factor, progress of development, and the fact that no standard type had been adopted. Insulated wire will require seven months, due to lack of braiding machines to handle the insulation.

(f) The Engineer Corps does not anticipate any especial difficulty in meeting requirements, as practically everything that they need is a commercial article for which there is normally a civilian demand. They will probably experience greatest difficulty in filling emergency demands from the Theatre of Operations.

(g) In the Chemical Warfare Service the exact date when the production of gas masks will meet requirements cannot be foretold, because the charcoal used in these masks is a strategic material, being made from cocoanuts. Also facilities for manufacture have not been developed to the point where they can meet requirements.

Military Phase of Procurement

The first thing, of course, in preparing plans, is to provide an organization. Planning sections for procurement now exist in all the branches in Washington and are being set up in the field wherever they did not previously exist. In the Ordnance Department and Air Service industrial districts the organization is entirely a planning one, having no current procurement functions; in others like the Quartermaster Corps and Engineer Corps, this work is merely added to existing functions. On account of the time factor of production, procurement plans must always extend well into the future, and in time of war the planning functions will increase rather than diminish.

As soon as the General Staff laid down a general mobilization scheme in March, 1922, the branches started figuring their requirements based thereon. In order that a definite mission might be assigned them, in this respect, they were instructed that these requirements should be completed and their plans for procuring the necessary supplies should be submitted by December 31, 1922. In order to insure the completion of this task, they were called upon for an estimate of personnel required and upon receipt of estimates fifty officers were definitely assigned to these tasks. The requirements in finished products are practically completed in all of the major items. The next phase so far as requirements are concerned will be to figure the strategic and critical raw materials involved in these finished products. The plans for procurement are in varying states of completeness. One or two branches have apportioned their requirements to their field agencies for the purpose of working up production data. Others have not proceeded beyond the point of getting up industrial districts and working upon a mission for their field agents.

The branches were instructed to make requisition on my office by December 31, 1922, for facilities required to meet their requirements. So far requisitions for allocation have been received for some 3,000 facilities, pertaining to the various branches. These facilities are now being carded in my office for the purpose of determining where overlapping occurs. They will soon be returned to the branches with authority to proceed to survey the facilities in question. When a facility has been definitely allocated to a branch, that branch knows that it can then approach the facility for the purpose of determining possibilities of production. This survey may be made by actual physical examination of plants or by contact with officials having knowledge of production capacity. It is expected that such allocations will hold for one year, at the end of which time the branches will be in a better position to requisition for all facilities required.

It is the duty of the War Department, of course, to adopt a form of war contract. Such a contract has been about completed as the result of a year's work by a Board of which General Peirce, of the Ordnance Department, is Chairman. This Board has done a very

fine piece of work and provided a single form of contract with which anything can be purchased for the War Department, from pins to railway locomotives, or anything manufactured from shoes to railway artillery. It has been designated a "fixed-price" contract; that is, it is intended for use where prices can be accurately determined and agreed upon in advance of signing the contract. This same board is now working on a flexible form of contract, which will be necessary in the case of those things for which no experience exists to guide business men. Such cases would arise, for example, in the manufacture of new or novel implements of war, or where it is necessary to reserve the right constantly to change specifications during the course of manufacture. By providing a fixed fee which will be diminished for failure to keep the price within certain limits and which may be increased for decreasing the price as well as the time of delivery, I believe we can adopt (in those cases where an agreed price is impossible) a flexible form of contract which will avoid all of the dangers of the so-called "cost-plus" contract.

Special attention must be paid to the selection of properly qualified personnel for inspection duty. There will be little time after war starts to educate inspectors. They must therefore be selected so far as practicable from men already qualified by experience in the particular line of industry whose output they are assigned to inspect. It is essential that inspectors of industry understand the degree of tolerance permitted in all specifications, otherwise there will be constant disputes as to whether specifications have been fulfilled, with consequent slowing up in production. Another point to be observed in this connection (I am, of course, only touching the high spots in this whole discussion) is that inspectors must be so assigned as to be relieved from the pressure of local business, social, political, and other affiliations. This is but a matter of simple justice to the Government, to industry, and to the inspectors themselves.

Economic Phase of Procurement

In order to deal logically with the problems which will arise in the economic phase of procurement planning, it is necessary to consider this subject under six heads: (1) capital; (2) labor; (3) facilities; (4) raw materials; (5) power; (6) transportation. During war the flow of raw materials to the Army as finished products in the form of munitions is expedited by such additional means as allocations, priorities, conservation, etc. I will touch upon these briefly where applicable.

(1) Capital. There is really but one phase of capital in which the War Department is fundamentally concerned in connection with a procurement program and that is to see that ways and means exist for financing facilities to which war orders have been allocated. This was done in the last war by the creation of the War Finance Corporation for the purpose of assisting banks in financing enterprises engaged in the production of munitions, and the War Credits Board created by the Secretary of War to make advances of funds to contractors furnishing supplies for the War Department. Similar agencies will be necessary in any future war. There is another phase of the subject, however, which is of more vital concern to the country at large. This is to see that capital does not take inordinate profits. The ways and means to attain this are variously described as "drafting capital," "taking the profit out of war," etc. It is not necessary to deal at length upon this further than to say that there are only four ways by which capital could be drafted. *First*, take money itself. This would be unnecessary since the Government already has the means of obtaining dollars by the issuing of bonds. *Second*, take over and operate plants. Authority to do this already exists in Section 120 of the National Defense Act, but this is very poor policy because it merely adds an additional burden to the Government's troubles in time of war and would not result in greater efficiency. Putting men in jail and seizing their property does not stimulate production, when that is what we want. *Third*, control prices. It is possible to do this within certain limits, but *price-fixing* is a very dangerous thing to undertake because, if prices are fixed at such a figure that industry cannot at least break even, they will prefer to surrender their facilities into the hands of the Government to operate. *Fourth*, take away excess profits. This was done during the World War and very successfully. It is not thoroughly realized that in one year of the war the United States raised by taxation nearly seven billion dollars. Of this total two billion seven hundred million was raised by tax on incomes, of which nearly one billion represents excess profits tax. There is also considerable misconception regarding "war-made" millionaires. Considering persons with *incomes* of $50,000 and over as millionaires there were

In 1916	17,085
In 1917	19,103
In 1918	14,495
In 1919	18,846
In 1920	15,742

So there were actually fewer millionaires in 1920 than there were in 1916.

(2) Labor. The question of the control of labor is a very delicate one and goes to the root of our modern industrial life. It is the fear of rise in price of commodities that starts labor troubles just as it starts trouble with capital. There is an inevitable rise in prices in time of war, caused by inflation, increased consumption, reckless buying, increased cost of production on account of scarcity of raw material and unskilled labor, high freight and insurance rates, increased taxation, hoarding of supplies and profiteering. The object of government should be directed—before even the declaration of war—to minimizing the evil effects of these elements. If this is not done prices begin to rise inordinately. Labor becomes restless. Capital must discount not only the probable increased demand for wages, but also the other various elements working to cause prices to rise. It will require the most energetic, intelligent and vigorous action to prevent rise in prices and hence unrest in labor and increased cost of production. The American Legion adopted at New Orleans last September the draft of a law designed to correct some of these matters. It was introduced in Congress by Representative Johnson of South Dakota and reads as follows:

"Sec. 2. That in case of war, or when the President shall judge the same to be imminent, he is authorized and it

shall be his duty when, in his opinion, such emergency requires it—

(a) To determine and proclaim the material resources, industrial organizations and services over which Government control is necessary to the successful termination of such emergency, and such control shall be exercised by him through agencies then existing or which he may create for such purposes;

(b) To take such steps as may be necessary to stabilize prices of services and of all commodities declared to be essential whether such services and commodities are required by the Government or by the civilian population."

I know of no legislation before Congress which would be so beneficial in controlling economic conditions as this program. It is, of course, very broad and it is doubtful whether Congress would consent to vest such powers in the executive. There is one thing, however, in connection with labor which can and should be done, and that is to prevent industries engaged in war-time production from becoming havens of refuge for "slackers." The American Legion proposes to prevent this in their legislative program for the draft by making it impossible to exempt any man between twenty-one and thirty, or such other age limits as the President shall fix, because of his industrial occupation. I am sure everyone will agree with this proposition. As the bulk of skilled labor is upwards of thirty years of age, this bill would not unduly interfere with the production of munitions.

It is vital that machinery be set up promptly on the outbreak of war for adjusting labor disputes, with power to write real decisions. This was not finally accomplished during the World War until a year after the declaration of war, when the National War Labor Board was created.

It is also necessary that machinery be created for the purpose of insuring a proper distribution of labor, diverting it from non-essential to essential, and avoiding congestion as well as under-supply. This was done after August, 1918, by making use of the United States Employment Service.

(3) Facilities. Where existing facilities are inadequate, as in the case of the Air and Ordnance programs, it is necessary to be guided by certain fundamental principles in seeking new facilities. During the war a great deal of trepidation was caused in industry by knowledge of the fact that the War Industries Board had under advisement declaring certain industries "non-essential." Strictly speaking, of course, no industry is non-essential, because a war should be carried on with the least disturbance possible to the ordinary life of the people. But of course some are more essential, or perhaps I might say less essential, than others. A list of these essential industries was made and orders went out to them to reduce greatly their production in order to conserve labor and raw materials. With a similar object, the Conservation Division of the War Industries Board undertook to eliminate waste so far as possible in industries, standardizing and eliminating the number of styles in clothing, and other items; requiring the use of wood containers instead of tin; by substituting materials which were plentiful for those which were scarce, for example, zinc for steel and other needed metals.

In connection with converting plants from peace time to war time production, certain principles should be observed; for example:

(a) Conversion of an existing plant producing less essentials to war essentials is preferable to the construction of a new plant because it leaves existing organizations and management intact, it creates a minimum dislocation of labor by reducing the housing problem, while existing power and transportation facilities can be utilized.

(b) Conversion should be directed along strata of manufacturing processes; for example, use forging plants for forgings; textile plants for textiles; confine delicate work and rough work to their own spheres.

(c) Conversion should leave undisturbed such key industries as machine tool makers, jigs, gauges, and die manufacturers, etc.

(d) Conversion should be directed along strata of raw materials; for example, metal workers should continue on metal work; wood-working plants on wood work, etc.

(e) Conversion should avoid creating inefficient facilities. Inefficient management in existing plants will certainly be more inefficient in a new one.

In connection with the allocation of facilities, it is very necessary to bear in mind the critical industrial area of the United States. Fifteen states produced over 93 per cent of our total war program in money value. Of these states, eight lie northeast of a line drawn from Baltimore, Md., to Erie, Pa. The very logic of necessity is forcing to the front the industrial capacity of the Mississippi Basin because the northeastern section of the United States is reaching the saturation point. Some other factors to be considered in allocating facilities are:

(a) The war load must be distributed as evenly as possible. Thus, of two facilities having approximately the same capacity, 50 per cent of each should be allocated rather than the whole of either. War orders should be looked upon not primarily as a source of profit but as a patriotic duty to be as evenly distributed as possible.

(b) Other factors being equal, facilities should be allocated as near raw materials as possible.

(c) New facilities must not be created unless requirements cannot be met by the allocation of all existing ones.

(4) Raw Materials. We are, of course, much better off than any other nation in the world in the matter of raw materials for a war program, but so wide is the range of demand of modern warfare that even we are in a helpless position regarding many items. We have applied the term "strategic" raw materials to those on which we are largely dependent as imports, and "critical" raw materials to those of which there is liable to be a domestic shortage. Thirty-one raw materials have so far been classed as strategic, viz.: antimony, camphor, chromium, cocoanut shells, coffee, cork, graphite, hemp, hides, iodine, jute, flaxseed, manganese, manila fibre, mica, nickel, nux vomica, opium, platinum, potassium salts, quicksilver, quinine, rubber, shellac, silk, sodium nitrate, sugar, tin, tungsten, vanadium, wool. Soon after my office was organized in July, 1921, I took up the question of enlisting the interest and activity of trade associations, technical societies, etc., in our war program. In connection with this matter of strategic raw materials we were fortunate in securing the enthusiastic co-

operation of the American Society of Mining and Metallurgical Engineers. Through their President, Col. Dwight, and in collaboration with the Bureau of Mines and the Geological Survey, they have set up committees of distinguished engineers who are now studying some of our strategic metals. At the present moment, they are confining their study to chrome, manganese, mercury, tin, tungsten and vanadium. I expect to obtain valuable results from the investigations of Colonel Dwight's committee. The fundamental thing to bear in mind in connection with strategic raw materials is that we must either maintain sufficient war reserves or assume that the seaways will be kept open by the Navy. Even on the latter assumption, we must have *some* war reserves, because we ought not have to wait to import essential items like nitrates until after war has been declared. The matter of reserve stocks is very important. For the moment, perhaps, these stocks are sufficient, with the exception of the grave shortage in Air Service planes and engines. But as our reserve stocks on hand are consumed (as in the case of Liberty engines) or deteriorate (as in the case of ammunition) we are brought face to face with the fact that our rate of production in a large number of vital items will not permit us to meet requirements in less than twelve months. If appropriations do not permit us to maintain the present reserves, the Army will have to conduct operations during the first twelve months of a war with the reduced stocks on hand. This fact was not known nor understood prior to the World War and resulted in much adverse criticism of the War Department which was wholly undeserved. This was more especially true since one of the first decisions made was not to interfere with the production program of our allies in American plants. Every possible effort must and will, of course, be made to speed up the rate of production, but it cannot be too often repeated or too emphatically emphasized that the rate of mobilization must depend upon the rate of procurement of those items regarded as vital, just the same as the possibility of success in operations depends largely on the ability to supply the troops engaged. Nor should we forget the fundamental principle that confronts all nations not independent in the matter of raw materials, which is, that the Navy must insure freedom of access to sources of strategic raw materials.

In this matter of raw materials the attention of Congress was called during the discussion of the recent tariff bill to the possible effects upon our domestic resources of certain tariff schedules. The War Department merely stated the case to the Committee without recommendations, the object in view being to call their attention to the fact that certain raw materials, such as manganese, are practically exhausted in this country and it would perhaps be a wise policy to so arrange the tariff as to encourage imports rather than encourage domestic production. The effect of the tariff on our strategic and critical raw materials is being watched.

(5) POWER. During the World War, to the surprise of those who had not given the matter careful study, certain industrial districts ran short of power. This was especially true in the Niagara district where the tendency to place orders without checking up on the ultimate consumption of power so overloaded the district that an embargo had to be placed upon any further orders. As a result of this, a Power Survey was started during the war. This is now being carried on under the supervision of the Chief of Engineers of the Army through his district engineer officers and in co-operation with the National Electric Light Association. When completed, it will give the first bird's-eye view of the power situation ever presented. The principal problem, of course, in connection with power is to connect up systems so as to divert to industrial districts as much power as possible. Within such districts, power may be conserved by applying night loads to day systems. By controlling fuel and power the Government is in a position to conserve labor and raw materials used in the less essential industries. Similarly, pressure can be brought to bear on the essential industries to compel them, when necessary, to take war orders.

(6) TRANSPORTATION. Whatever one may think of Government ownership of railroads in time of peace, no one who has given the question any study can escape from the conclusion that there must be some form of Federal *control* of transportation during any major war. The very natural tendency of transportation systems is, of course, to maintain only as much rolling stock as is required for their peak load during normal years. The saving in pooling cars is well illustrated by the control of sleeping cars by the Pullman Company. The railroads are thus enabled to meet the summer movements to the shore and mountain resorts and the winter movements to Florida and California with a minimum of rolling stock. Rail transportation must be conserved in time of war through embargoes, use of inland waterways, opening new ports, use of auto trucks, cutting down demurrage and quick repair of "bad-order" cars. The amount of rolling stock continually in "bad-order" is astonishingly large. It averages from 5 per cent to 10 per cent in the case of cars, and from 15 per cent to 20 per cent in the case of locomotives. On July 1st, 1922, at the time the shopmen's strike began, 324,583 cars (14.3 per cent) and 11,318 locomotives (25.8 per cent) were officially classed as in "bad-order." This, of course, indicates at once one point of attack in a solution of rail transportation in time of war. In a major effort (the only kind of a war we are here considering) every industry must be given a priority rating which will determine its procedure in the matter of raw materials, fuel, power and transportation. The main difficulty in connection with priorities is to guard against the tendency to give everything the highest priority rating, which, of course, defeats the object of establishing priority. When properly administered, priorities offer the best possible means to insure a *balanced* war production program.

Relations With Navy Department

One of the most important functions of the Assistant Secretary of War in connection with procurement planning is to insure co-ordination of the War Department program with the Navy. This has been done by the creation of an Army and Navy Munitions Board. Briefly, the order provides that this Board shall consist of the Assistant Secretary of War and the Assistant Secretary of the Navy. *A Procurement Policy Committee* is created which recommends policies regarding procurement of supplies and co-ordination of the work of the other committees. Other

committees consist of the chiefs of branches having corresponding functions in the two services, and are in general explained by their titles. For example, there is a General Supply Committee, an Ordnance Committee, an Aircraft Committee, a Medical Committee, a Chemical Warfare Committee, a Public Works Committee, a Power Plant, Machinery and Machine Tool Committee, and a Marine Construction Committee. One of the principal functions of these committees will be to decide upon proposed allocation of facilities desired by the two services. Meetings have been held by the Procurement Policy Committee looking to an agreement for allocation of facilities to hold during the current year.

Relation With Super-Agencies

After the War and Navy Departments have gone as far as they can in the matter of co-ordinating their war programs, there still remain many things to be done in mobilizing the nation for war. Our experience of the World War indicates that in all likelihood there would be required in another major conflict, super-agencies such as a War Industries Board, a Price Control Committee, a Labor Administration, a Food Administration, a Fuel Administration, a Railroad Administration, an Administration of Communications, a War Finance Corporation, and a War Trade Board. The same reasons which required the creation of these super-agencies in the last war will exist in the next. The proper thing, therefore, to do is to plan for them in time of peace. Space will not permit me to go into detail regarding what has been planned thus far in connection with these agencies. The scope of all of them lies, of course, outside and beyond the War Department, but, inasmuch as it is not made the ministerial duty of any other official of the Government to plan for their operation in time of war, and it does appear that under the law the Assistant Secretary of War is required to give consideration to them, I am, in connection with the War Plan in my office, giving attention to the legislative requirements and executive orders which would be necessary to set up these super-agencies in the event of war. Fundamental principles of organization would seem to indicate that all of these super-agencies should be merged into one very flexible organization, responsible to a single head, who would report directly to the President.

It is inconceivable with our vast resources in material, combined with the ingenuity and intelligence of our people, that America should ever be defeated in war. You are all familiar with the military maxim that "It is pardonable to be defeated, but never to be surprised." We *were* surprised in the matter of industrial preparedness for the World War. We must plan so that those errors will not be repeated. It is not in a spirit of egotism, therefore, but rather a report of my stewardship when I say that I am certain that more has been accomplished in the past eighteen months looking to industrial preparedness than has ever been accomplished before in the history of the War Department.

APPENDIX 1.

RELATIVE EXPANSION, PEACE AND WAR, OF THE SUPPLY BRANCHES

(a) Expenditures 19 months of War vs. 19 months of Peace (based on 1922-1923 appropriations.)

	War	19 Months Peace	Proportion Peace	War
Quartermaster Corps	$8,074,018,000	$73,576,154	1	110
Ordnance Department	4,087,347,000	10,352,929	1	408
Air Service	859,291,000	20,108,327	1	43
Engineer Corps	638,974,000	1,588,875	1	426
Medical Department	314,544,000	1,583,327	1	210
Signal Corps	129,920,000	2,899,587	1	43
Chemical Warfare Service	83,299,000	950,000	1	88

(b) Relative size of the United States Army, March, 1917, and November, 1918.

Total Army—Peace	190,000	
War	3,665,000	
	Ratio of Increase	1 : 20
Line of the Army	Ratio of Increase	1 : 14
Supply Branches	Ratio of Increase	1 : 43

	War	Peace	
Corps of Engineers	394,000	3,000	1 : 131
Quartermaster Corps	331,000	8,000	1 : 41
Medical Department	300,000	7,000	1 : 43
Air Service	202,000	9,000	1 : 22
Ordnance Department	64,000	1,000	1 : 64
Signal Corps	52,000	3,000	1 : 17
Chemical Warfare Service	18,000	600	1 : 30

APPENDIX 2.

THE FIFTEEN LEADING INDUSTRIAL STATES WHICH FURNISHED 93.2 PER CENT OF THE WAR SUPPLIES IN THE WORLD WAR.

	Per cent of Supplies Furnished	Per cent of Population engaged in mfg.	Per capita value of mfg. prod.
1. New York	19.3	14.7	$855
2. Pennsylvania	15.1	15.2	839
3. Ohio	9.2	15.3	886
4. Delaware	7.6	14.8	746
5. Massachusetts	7.5	21.1	1040
6. Illinois	7.0	12.4	906
7. Connecticut	6.6	24.5	1009
8. Michigan	6.3	15.0	940
9. New Jersey	4.6	19.1	1168
10. Maryland	2.03	11.4	803
11. Wisconsin	1.9	12.1	718
12. Tennessee	1.8	4.8	238
13. Indiana	1.7	11.3	649
14. Missouri	1.7	7.2	470
15. Rhode Island	.7	24.5	1236

Tendencies in Ammunition Design

By

J. K. CRAIN

THERE are three principal general demands that influence ammunition design. They are:

(1) The purpose for which the ammunition is to be used,

(2) The desire for an increase in range,

(3) The desire for an increase in accuracy,

There are many other desirable qualities that also influence the design of ammunition, such as the ease with which it may be manufactured, the cost, the availability of raw materials, increase of safety in using, etc. The two principal requirements that are most clear-cut are increased range and increased accuracy, and these two ordinarily do not go hand-in-hand. Usually a compromise between the two must be accepted.

The desire for greater range and demand for the heavier projectiles to pierce armor led to the change from the round cannon ball to the cylindrical projectile. Rather, I should say, to the elongated projectile, for the Englishman Whitworth some time about 1850 invented and manufactured a gun with a hexagonal cross-section which moved along the axis of the bore on a helix of steep inclination. The angle of inclination of this unusual rifling, for such it was, was about 15 to 20 degrees. Our modern rifling has an inclination of about 6 to 7 degrees.

The projectile that was fired from this gun also had a hexagonal cross-section through the body portion. It was, therefore, a nut that was driven along a screw—the interior of the gun. This projectile required no rotating band. The energy consumed in the gun by the work done on the rotating band was not required by the Whitworth projectile. The Whitworth projectile could, therefore, have a greater weight for its given pressure in the bore than the present standard type of projectile. It is interesting to note here, that some of these guns were sent to the Confederacy from England and that two of them, with a number of projectiles, are now resting quietly on the battlefield of Gettysburg.

The French had revived the Whitworth theory and were experimenting with it in 1914. They continued their experiments during the World War, one of their principal aims being to prolong the life of the guns in service. With this in view they experimented with rifled projectiles. The theory that spurred them on was that erosion results in the stripping of the rotating band and this finally causes the withdrawal of the gun due to inaccurate ranging. Now, if the projectile were rifled there should be no slipping until the rifling of the gun was nearly obliterated. Old guns were modified for the tests. Projectiles heavier than service projectiles were successfully fired, but slipping occurred much earlier than was anticipated, so that the idea of extending the life of existing guns by rifling the projectiles did not materialize. It is worthy of note, however, that the projectile of the German long-range gun was rifled in addition to having two copper bands.

One of the first methods employed to make the elongated projectiles take the rifling was to place lugs on the projectile. This scheme, like the Whitworth idea, gave way to the copper rotating band and thus the use of the latter became universal.

Apparently, no great importance was attached to the size, location, etc., of this rotating band. It was supposed to perform the dual purpose of acting as a gas check and making the projectile take the rifling of the gun. The earlier types were narrow, with a lip at the rear. This lip was to insure a gas-tight joint. In response to demands of the Coast Artillery some years ago, bands were materially broadened. This demand arose because of erratic ranging of certain seacoast guns that had fired a great many rounds. It is probable that the narrow bands were stripping somewhat and that the projectiles did not get proper rotation. The lip was still retained. However, during the late war very erratic ranging was obtained by the 6-inch seacoast gun mounted on a movable carriage. It occurred to the personnel working on this problem that the lip on the rotating band was causing erratic ranging. The specific reason assigned was that the excess copper in this lip was forced to the rear and formed a fringe projecting at the back of the band and clear of the body of the projectile. As the projectile left the gun the gas pressure underneath this fringe plus centrifugal force forced it up and thus an irregular ring, or more probably varying segments of a ring, encircled the projectile. This made the resistance offered by the air ununiform around the projectile and caused irregular flight.

Experimental firings were held at Aberdeen Proving Ground with rotating bands modified by cutting off the lip. The results were very gratifying. With an elevation of 40 degrees and a muzzle velocity of 2,600 f. s. the modified banded projectiles gave an increased range of 4,500 yards and the average dispersion was reduced to one-fourth of that obtained with unmodified bands.

It is now conceded by most authorities that erosion is not caused by the escape of gases past the projectile. Experiments have been made abroad firing a projectile with a hole bored entirely through it along the axis. It was found that there was no evidence of powder gases having passed more than a couple of inches down this hole. In other words, little or no gas got through the hole ahead of the projectile. (Journal U. S. Artillery, Vol. 51, No. 4, Major O. Veblen and Lt. P. L. Alger).

Supporting the view that the flow of gas past the projectile was not so material as formerly considered and the following incidents:

(1) Firings were conducted with an 8-inch gun in 1918 at Aberdeen Proving Ground in which the rotating bands had been trimmed down until daylight could be seen around the shell loaded into the gun. Using this type of projectile the range was increased by 2,000 meters over the range of the standard projectile and the dispersion became one-sixth what it had been. (Journal U. S. Artillery, Vol. 51, No. 4, Major O. Veblen and Lt. P. L. Alger).

(2) During 1922 in firing a 240-millimeter howitzer, the bore of the mortar was badly damaged by the fifth round of a series. The bore was bulged over a distance of over thirty inches, the maximum expansion being about one-fourth inch. In addition, the rifling was torn and flattened in numerous places along the bore. The damage was not observed and

an additional round was fired. This sixth shot struck the target at a range of about 14,000 yards.

At Fort Sill projectiles for the 155-millimeter howitzer have had their accuracy materially increased by machining off a portion of the rear of the rotating band. Accordingly, the design of all rotating bands now employs the guiding principle that there must be space provided into which the excess copper can flow without creating a fringe.

It may be said, then, that the tendency of the design of rotating bands has been from no band to an excessive one, and that now the pendulum has swung the other way and the size of rotating bands is being decreased.

In addition, it has been found that the location of the rotating band as well as its size and form may make a considerable difference in the efficiency of the projectile. In the 240-millimeter howitzer projectile the original short, steep boat-tail was changed to a long boat-tail and the rotating band was moved forward about five inches. These two modifications increased the range of this projectile about 2,000 yards and greatly increased the accuracy of fire. The short, steep boat-tail actually reduced range and accuracy as compared with the square base.

When the idea of using rifled cannon came into being the projectile at once changed from a round ball to an elongated form. It is again interesting to note that the Whitworth projectile had a well-defined point and was tapered at the rear, or as it is now called, it was boat-tailed. Both of these valuable points were lost sight of and for a considerable time the cylindrical projectiles had rather snub points and square bases; that is, there was no taper at the rear.

In the effort to obtain an armor-piercing projectile, a soft-nose cap was placed on the end of the projectile. It was at once recognized that this was detrimental to range and to overcome this defect a false ogive was placed over the soft blunt cap. The use of this false ogive gave a very material increase in range and also increased remaining velocity which increased armor penetration, and at once the field was opened for a change in design of the point of nearly all projectiles. Some projectiles for the German 42-centimeter howitzer were found near Verdun. These were of two types, one of which was nearly all point. The projectile was fully five feet long and the tapered portion extended along about four feet of this length. This made a very peculiar looking projectile and it was evidently designed to increase the range of that weapon, which had a very limited trajectory.

The false ogive confers the benefit of reducing air resistance and at the same time allows the center of gravity of the projectile to remain well back from the head. It also has the advantage of not unduly increasing the weight of the projectile.

In addition to the change in form of the point, a change in form of the rear of the projectile has been brought about, although more slowly. This change consists in machining an inclined surface at the rear of the projectile instead of cutting it off sharp as had been done previously. It has been found that such a taper results in considerable increase in the range of the projectile. The reason for this is that the air passing along the projectile is directed toward the axis of the projectile, whereas in the old type it was parallel to the axis. As a consequence, in the taper type the vacuum or partial vacuum in the rear of the projectile is decreased in size and therefore the projectile is less retarded. The length and degree of taper that any projetile should have is determined by experiment, as no exact law has been found covering this design. It is known that too sharp a taper is detrimental and that too short a taper is also detrimental. At the present time, therefore, it is a question of cut and try to get the best results.

It has been determined that the angle of boat-tail should not exceed about 9 degrees. Beyond this point erratic results are obtained which are probably due to varying action of the powder gases on the tapered base at or near the muzzle of the gun.

Another characteristic of the projectiles and one about which there has been discussion for many years, is the proper ratio of the weight of the bursting charge to the total weight of the projectile. In the seacoast guns before the World War there existed two projectiles; one a shell of high capacity and the other a shot of low capacity.

The 3-inch field gun of pre-war days fired a shell weighing 15 pounds that contained .9 pound of explosive, which is 6 per cent of the total weight. The 75-millimeter shell that was chiefly used in France weighed 12.18 pounds and contained 1¾ pounds of explosive, which is 14 per cent of the total weight. The most modern 75-millimeter projectile that the Ordnance Department is now experimenting with follows the lines of the French projectile. The percentage of bursting charge is about 10 per cent.

The natural target of the seacoast artillery is an armored ship of war; one of the most important targets of the divisional artillery is personnel. The French laid stress on the moral effect of high bursting charges and we have followed their lead. Experiments have been conducted at Picatinny Arsenal employing 75-millimeter shell of identical form, but with varying amounts of bursting charge and with varying character of metal and of varying total weights. Here are some data on a few of the wider varying types:

Metal	Total Weight lbs. ozs.	Wt. of Bursting Charge lbs. ozs.	Per cent of Bursting Charge	Min. Frag. in 60 per cent Wt. of Shell
Cast Iron	13 — 8½	1 — 2	9.0	2339*
Steel	11 — 4½	1 — 10	16.9	209
Steel	13 — 11½	13½	6.3	20
Heat-treated Steel	9 — 4½	1 — 14½	21.2	250

* Less than 60 per cent.

It will be noted that the size of the fragments increases with decrease in amount of bursting charge used in the shell. Conclusions should not be too hastily drawn from fragments alone, as the velocity with which they start out is important. A great deal more work will have to be done to establish a basis of deciding the best percentage of bursting charge to be used against personnel. It will be difficult to ever definitely decide this point, as the moral effect can scarcely be measured. The metal employed in mobile artillery projectiles will depend, to some extent, upon the percentage of explosive desired. With inferior metal the wall of the projectile must be made thicker and the amount of bursting charge correspondingly reduced. The reason for using a cheaper metal such as cast iron would be the question of reduced cost and more rapid production. It is not likely that any other projectiles than forged steel will be used unless we become involved in a war of great magnitude and long duration.

Fuzes

When we entered the World War the percussion fuze was a base type fuze. The question of a superquick fuze had never been considered. The time fuze was a powder train combination fuze. As we adopted the French guns we likewise adopted the French ammunition. Their fuzes were of various types, such as the superquick, without delay, short delay, long delay, etc. In nearly every case the form of the fuze was different. The form of some was so detrimental

to ballistics of the shell that an eminent French ballistician once asked if the designer of one type of fuze had ever seen a projectile.

The use of this matériel during the war developed certain defects. Some of these were that the fuzes were not bore safe, and quite a number of premature explosions resulted. The variety of types was bad. The fuzes were issued separately and the artillery were required to fuze the projectiles at the guns. The difficulties of supply were enormous and handling at the gun was awkward. The Ordnance Department has, since the war, attempted to obtain point detonating fuzes that had the following qualities as improvements over the war-time fuzes:

(1) Be bore safe;
(2) Reduce the number of types;
(3) Be capable of being issued loaded in the projectiles;
(4) Not interfere with ballistics of the projectile.

Considerable progress has been made along these lines. The bore safe feature has been obtained by reducing the amount of fulminate in the detonator and by using a rotor carrying the detonator out of line with the firing pin until the projectile leaves the gun. At this time centrifugal action causes the rotor to revolve until the detonator is in line with the point of the firing pin.

In order to reduce the number of types it has been decided that a combination fuze that could be used either as a superquick or as a short delay fuze would be a suitable all-purpose fuze for divisional artillery and for certain other larger guns.

In addition, there has been developed a supersensitive fuze for the 37-millimeter gun that will function upon impact with airplane fabric.

One difficult condition that the fuze designer is confronted with is the considerable differences they encounter in the velocity and rotation of the howitzer projectile as compared with the similar qualities of the high-pressure gun projectile. The Mark IV fuze used in the 155-millimeter howitzer should not be used in the 155-millimeter gun. The reason for this is that the small restraining spring in the Mark IV fuze must be weak in order that the fuze will function with a low velocity howitzer projectile. When this fuze is fired from the 155-millimeter gun the retardation of the projectile shortly after leaving the gun is occasionally sufficient to overcome the resistance of this weak spring and the fuze functions a short distance in front of the gun.

On the other hand, the Mark IV-Star fuze designed for use in the gun has a spring three times as strong as that used in the howitzer. Consequently, if this Mark IV-Star fuze should be used in a howitzer in many cases duds would result with low striking velocities. Experiments are being conducted at the Aberdeen Proving Ground with springs of strength intermediate between the present Mark IV and Mark IV-Star in an effort to obtain one fuze that may be used in both the howitzer and the gun.

Due to inaccuracies of time fuzes, particularly when used in varying and high altitudes, the proposition of a mechanical time fuze has been made a very attractive one. Various types were manufactured during the war. Those made in America do not meet all the requirements of the service. A commercial company has been conducting experiments for the past two years in an effort to improve the type. The Germans claim to have developed a satisfactory mechanical fuze. Experiments will be conducted along this line until a satisfactory mechanical time fuze has been produced.

In the meantime experiments are being conducted with a view of obtaining uniformity of the powder train time fuze. This investigation is along two lines; first, to attempt to get a fuze that will be uniform in burning at the same elevation, whether low or high; and second, to obtain a fuze that will be uniform in burning at both low and high elevations. Attempts are also being made to waterproof the powder fuzes so as to prolong their accuracy life.

Propelling Powders

The advance in propelling powders was very slow from the time of the invention of black powder until several hundred years later when smokeless powder was discovered. From that time forward there have been many developments, although all of them were not successful. The standard propellant in this country and in France before the war was nitrocellulose powder. The United States used multi-perforated grains and the French used strips. Germany, and to a certain extent England, used nitroglycerine powder.

The first development of the war which affected powder materially was a demand for the tremendous quantities used in the battles. The French had been making nitrocellulose powder by the water-dry method, but until the du Pont and other companies received their enormous orders from Europe the water-dry process had not been much used in this country. It was practically impossible to meet the demand by the old air-dry process and consequently the water process became the standard one for small-caliber weapons. In this process the smokeless powder, after a short time spent in the solvent recovery, is placed in receptacles containing water, the temperature of which is gradually raised until it is about 55 to 60 degrees C. When the residual solvent has been reduced to the desired amount, the water is drawn off from the powder and the powder transferred to air-dry houses where the external moisture is reduced to the desired amount. As an example of the time saved 3-inch field-gun powder required 157 days by the standard air-dry system, whereas the same powder was dryed in fourteen days and eleven hours by the water-dry system. The water-dry powder has proven to be the equal of the air-dry powder in every respect except that of long stability. This can only be determined over a period of years. Up to the present the water-dry powder has proven equally good.

The next development attempted was to still further accelerate the drying process by the use of alcohol. The theory of the alcohol-dry system is that the alcohol will readily drive the ether out of the powder. In turn the alcohol can be readily removed by water. This method will permit the drying of powder in a few hours. While it has not been used sufficiently to be finally standardized and adopted, yet certain lots of powder have been made by it and fired with good results. These lots varied from the 155-millimeter gun powder up to the 12-inch seacoast gun.

The necessities of the war emphasized the need of a flashless powder, also of a non-hygroscopic powder. Prior to our entrance into the war, experiments had been made at Picatinny Arsenal to develop a flashless powder. Encouraging results had been obtained, but they were not considered satisfactory and none was used by the American Army in the war. Since the war, the problem has been pursued by both Picatinny Arsenal and the du Pont Powder Company. Powders in which the flash had been greatly reduced have been produced at both places, and 1,000 rounds of 75-millimeter ammunition were made up and sent to Fort Sill and Fort Bragg for test by the Field Artillery. Five hundred of these rounds were loaded with Picatinny product and 500 were loaded with the du Pont powder. These powders were quite flashless, but these good qualities have so far been obtained by the sacrifice of a part of the

smokeless qualities. We are relying upon the tests at Fort Sill and Fort Bragg of this ammunition to determine how much weight should be given to the smokeless qualities, how much weight to the flashless qualities, or whether a compromise would be better than either. It is interesting to note that in obtaining this flashless powder at Picatinny, the use of nitroglycerine was reverted to.

The use of nitroglycerine powder would be a decided advantage to the makers of ammunition since, due to its more plastic qualities, long grains or strips can be made that will retain their shape. This is not true of nitrocellulose powders. The fact that grains of great uniformity and of unusual size and dimensions can be made of a nitroglycerine powder makes it more easy to design a powder for a given gun than is the case with a nitrocellulose powder.

Before the war the charge for howitzers and mortars was made up of a base charge with varying increments for different zones. For the seacoast mortars the charges were made up of one section of varying weights.

The use of aliquot part charges for mortars and howitzers has been sought after for a long time. There have been developed and issued to the Coast Artillery since the war aliquot part charges for 12-inch seacoast mortars. The issues were limited in number and were to obtain service test. Some reports have come in from the Coast Artillery and in general they are favorable to the aliquot part charge as issued. The chief advantage of the charge is the economy in use of powder for so long as any of the parts remain, charges can be made up for any zone.

An aliquot part charge has also been made up for the 155-millimeter howitzer. This consists of four sections each one-fifth of a charge and two sections each one-tenth of a charge. One hundred rounds of these have been sent to Fort Bragg for service test. No report has as yet been received from these 100 charges.

One of the chief enemies of the accuracy of ammunition is the effect of moisture upon the propelling charge. Ammunition that is in the hands of troops in the field must necessarily be exposed to moisture. This is particularly true in separate loading ammunition in which the charge is not in air-tight containers. Disastrous short shots will result if the powder for the 155-millimeter howitzer or gun absorbs very much moisture. The great value of non-hygroscopic powder is very evident.

Experimental firings of the 75-millimeter flashless powder in the 1920 model field gun emphasized the importance of proper ignition of the propelling charge. In the first firings the service 49-grain primer was used. A number of hangfires resulted and it was decided that the primer was at fault. Accordingly, a primer containing 100 grains of powder was made by adding an extension to the 49-grain service primer. This 100-grain primer eliminated the hangfires in the flashless powder. Based on this firing, it was thought that the 49-grain primer had very little factor of safety when used with the service charge. Experimental firings were then had with the present standard service smokeless powder using 49-grain and 100-grain primers. In the 75-millimeter guns of French and British type no appreciable improvement was noted when the 100-grain primer was used, but in the new 75-millimeter field gun, Model 1920, a decided improvement was noted when the 100-grain primer was used in connection with present standard service smokeless powder. As an example, the following comparison is given:

Primer	Mean Velocity	Mean Variation in Velocity	Mean Pressure *pounds*	Mean Variation in Pressure *pounds*
49-gr.	2340 f. s.	13.2 f. s.	34,790	1340
100-gr.	2306 f. s.	3.0 f. s.	31,890	548

This gun has a much larger powder chamber than the French and British 75-millimeter type.

Explosives

The chief explosives now used in bursting charges of projectiles are Explosive "D" for armor-piercing projectiles and T. N. T. for all others. During the war, as a result of the shortage of T. N. T., a mixture of T. N. T. and ammonium nitrate was employed. This was called "Amatol" and is satisfactory for war uses. For a long period of storage it is not believed to be so satisfactory, as the two components tend to separate from each other. If T. N. T. is available in sufficient quantities, it will continue to be used as a standard shell filler in field artillery projectiles. T. N. T. is loaded into shells by melting and pouring into the shell. Explosive "D" is loaded by being forced into the shell by hydraulic pressure. The density of loading of projectiles is very important. If the bursting charge is capable of movement in the projectile on setback in the gun, there is a possibility of a premature explosion in the gun. This condition was demonstrated in some firings held at Fort Sill in which a premature was obtained in an 8-inch howitzer with an unfuzed shell. Proper density of loading is also required to prevent duds that might be occasioned by too wide an air-gap between the booster and the bursting charge, this air-gap being occasioned by the shifting of the bursting charge.

Bombs

The first explosive bombs like the first artillery projectiles were spherical. These were the Zeppelin bombs. The evolution of bombs followed the general line of development of artillery projectiles and now most bombs are elongated with tapered bases. The amount of explosive contained is large, and varying action is obtained with different fuzes.

Progress has been made on improving war-time fuzes to make them more safe in handling and more certain in action. Furthermore, the fuzes are required to remain "safe" when for any reason a bomb is dropped and it is not desired that it explode. The large amount of explosive content of bombs renders them exceedingly destructive. The tendency is to go to large sizes. How far this will lead is undetermined. Future experience will be the guide.

We have observed that during peace, development was relatively very slow as compared to the great advances made during war. The reasons are, of course, obvious. The importance of ammunition in war and the amount of money that is available for obtaining and improving it and experimenting with it are quite different from the peace-time situation. However, the Ordnance Department will prosecute this problem with all its energy, and, fortunately, there is a considerable stock of ammunition on hand that can be used in further experiments. It is hoped, therefore, that the next few years will be fruitful ones in so far as the development of ammunition is concerned.

Sympathetic Detonation

By

C. G. STORM

IT has long been known that the detonation of a mass of high explosive may cause the detonation of another mass of explosive separated from the first by an inert medium which may be either gaseous, liquid, or solid. The secondary charge may be either the same kind of explosive as the initiating charge, or one of an entirely different nature. The distance through which detonation may be propagated depends upon a number of factors, among which are included the properties of the explosives concerned, such as sensitiveness and rate of detonation, the mass of the initiating charge, the nature of the intervening medium, and the nature of the supporting material on which the charges rest. The effect thus produced is commonly known as detonation by influence, or sympathetic detonation.

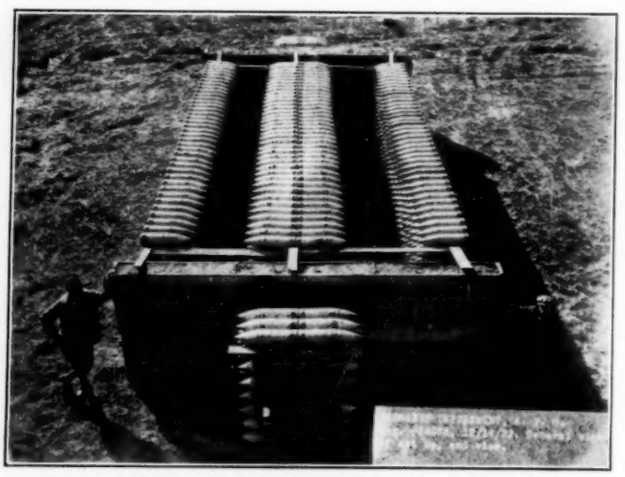


Fig. 1. Eight-inch High-Explosive Shell Ready for Sympathetic Detonation Test

The proof that explosives could transmit such effect at a distance was probably first demonstrated by the experiments of F. Abel [1] and J. Trauzl,[2] who showed that submarine mines of guncotton could cause the explosion of other mines at such distances that the intervening water precluded the effect being transmitted by solid particles or hot gases. The military importance of this fact is indicated by the experiments of Gen. H. L. Abbot,[3] who, in order to determine the proper spacing of submarine mines, measured the concussion propagated under water by an ingenious arrangement of lead compression gauges. He showed that, assuming water to be entirely incompressible, the energy (E) transmitted is equal to

$$E = m\frac{\sqrt{P}}{d^2}$$, where d=distance from the explosion center, P=weight of explosive, and m=a constant, depending on the kind and conditions of the explosive used. In other words, the force transmitted *under water* is in inverse proportion to the square of the distance and in direct proportion to the square root of the weight of explosive.

Two theories have been offered in explanation of sympathetic detonation: (1) That the explosion of the secondary charge is produced by a synchronous relation between the molecular movements of the gases evolved by the initial explosion and those of the molecules of the secondary charge. In other words, that waves of definite amplitude set up in the intervening medium by the initial explosion, cause the molecules of the secondary charge to take up a "sympathetic" motion which results in detonation of the charge. Such effect is compared to the sound emitted by a string of a musical instrument when set in sympathetic vibration by a sound of proper wave length; (2) That the secondary explosion is effected by the *kinetic energy* of the molecules of gases of explosion, propelled at a high rate from the initial charge, the effect produced on the molecules of the secondary charge being sufficient to cause their explosive decomposition. Both of these theories have their adherents at the present time.

Champion and Pellet [4] showed that a small quantity of nitrogen iodide placed in one end of a tube 7 meters long, was exploded by the explosion of another small quantity in the opposite end of the tube, and that the effect was not due to a puff of air, but to vibrations of the air. Nitrogen iodide, placed on the strings of a bass viol, exploded from the sounding of strings having a rate of vibration in excess of 30 per second, but not from the effect of vibrations of lower rate. Berthelot,[5] on the other hand, argued that these detonations were a function of the intensity of the mechanical action, rather than of the rate of vibration. This argument is substantiated by the fact, shown by many investigations in recent years,[6] that for every explosive under given conditions there is a minimum quantity of any detonator which will initiate detonation, any less quantity being ineffective.

A modification of the above theories was proposed by Threlfall [7] as a result of his investigations. He concluded that the shock of explosion was communicated through the surrounding medium by one or more of the following: (1) Actual movement of the products of explosion: (2) an undulating motion set up in the medium; (3) vortex ring motion.

Admitting that detonation progresses through a mass of high explosive as a form of wave motion, with a velocity which may be anywhere from 3,000 to 10,000 m. per second, depending on the nature of the explosive, its density, confinement, etc., it is apparent that this wave motion must be transmitted to the surrounding medium through which it is propagated at a rate which depends on the velocity and pressure of the originating explosion, and which decreases as it proceeds from its source.

Mach, as early as 1877,[8] measured the velocity with which the air waves were propagated by the explosion of small charges of nitrogen iodide. His results were as follows:

Distance from source (m. m.)	Velocity (meters per sec.)
80	756
137	540
254	453
400	416
977	373

At a distance of several meters the waves were found to have the normal velocity of sound in air (340 meters).

Vielle [9] found that the impulse proceeded through the air from the explosion of a detonator containing 0.63 gram of mercury fulminate, as follows:

Distance from source (centimeters)	Velocity (meters per sec.)
32.6	1073
53.2	1015
131.1	969
235.9	821
386.4	575

16 meters from the source, the wave still possesses a velocity higher than that of a normal sound wave.

Dautriche, [10] by a method involving the use of detonating fuze (cordeau detonant), measured the speed of this shock wave at a distance of 50 mm. from the surface of a 100-gram cartridge of explosive. When the explosive detonated was a dynamite with a detonation velocity of about 7,000 m. per sec., the explosion wave 50 mm. from the charge had a velocity of 3,000 meters per sec. When the explosive used was cheddite having a detonation velocity of 3,000 m. per sec., a result of 950 m. per sec. was obtained.

Comey [11] made experiments with "straight" nitroglycerin dynamites in a similar manner, to determine the velocity with which detonation was transmitted through the air from one cartridge of the explosive to the other. The general nature of his results is shown by the following figures for 60 per cent dynamite having a normal rate of detonation of 5,795 meters per second. Through the first 10 inches of air space the average velocity was 5,183 m. per sec.; between 10 inches and 20 inches, 3,650 m. per sec.; between 20 inches and 30 inches, 3,175 m. per sec.; and between 30 and 40 inches 1,460 m. per sec.

In much larger tests at Cummersdorf [12] in which 1,500 kilograms of gelatin dynamite were detonated, air waves with a velocity of 800 m. per sec. were noted at a distance of 50 meters, and even at a distance of 250 meters the velocity of the air waves had not been reduced to that of normal sound waves. Tests with smaller quantities of pieric acid, cheddite and black powder were made by the French Explosives Commission [13] with results of similar nature.

It is apparent from all of these investigations that the wave of disturbance set up in the air surrounding a charge of explosive, by the sudden generation of the gases of explosion, is propagated with considerable velocity, and experiments by many investigators have shown that this wave is capable of bringing about the explosion of a second charge of explosive, placed within a suitable distance of the first. No definite proof is available as to whether the "sympathetic" explosion is the result of synchronized vibrations or is due solely to the violence of the shock transmitted. It is certainly true that the greater the mass of the explosive used as the initiating charge, the greater will be the distance at which sympathetic explosion of a given charge will be effected, all other conditions being equal.

Charles E. Munroe [14] conducted a series of small scale tests in 1890 to determine the distances at which charges of various explosives would be "sympathetically" detonated by a standard charge of 100 grams of compressed guncotton (density 1.2871). The charges, unconfined, except for paper containers, were placed on a piece of one-inch wrought-iron armor plate and the distances separating them varied to determine the maximum distance through which detonation would be transmitted. Munroe observed varying degrees of detonation, by noting the impressions made on the plate, the effect diminishing as the secondary charge approached the point at which it ceased to be detonated. He found that the weight of the secondary charge could be varied between wide limits (30 g. to 100 g.) without affecting the distance through which detonation occurred. A general summary of his results is as follows:

Relative Sensitiveness to Detonation by Guncotton

Secondary Charge	Max. Distance at which Detonation Occurred (centimeters)
Guncotton	10
Explosive Gelatin (camphorated)	20
Judson Powder	25
Emmensite	30
Rackarock	32
Bellite	50
Forcite No. 1	61
Kieselguhr Dynamite No. 1	64
Atlas Dynamite No. 1	74

It is important that commercial blasting explosives should be capable of transmitting detonation from one cartridge to another even when an appreciable air gap separates the cartridges, because in loading deep drill holes the continuity of the explosive charge cannot always be assured. Explosives used for ditching purposes must be especially sensitive to sympathetic detonation, so that the explosion initiated in the first of a series of holes spaced relatively close together may be transmitted to each successive charge in the entire series of holes. One of the tests regularly made by the Bureau of Mines on mining explosives, and also employed in routine tests by various explosive manufacturers is known as the "Explosion-by-Influence Test." Two cartridges of the explosive are suspended vertically end to end with a measured air gap intervening. The lower cartridge is exploded by means of an electric detonator embedded in its lower end. The minimum distance at which no explosion of the upper cartridge occurs in three successive trials is determined within 1 inch. The second cartridge is not considered as having exploded if any part of it can be found. In various modifications of this test, used by different manufacturers, the cartridges may be suspended horizontally in the air, or placed end to end on the ground or on a rigid support, as a steel rail or plate. Sometimes the two cartridges are placed in a roll of paper so that the column of air separating them is under slight confinement.

During the past year the Ordnance Department has been conducting a program of tests at the Aberdeen Proving Ground to determine the susceptibility of high explosive shell to sympathetic detonation.[15] Although it had been well established from previous war experience in Europe that the detonation of one shell in a pile would cause the simultaneous detonation of the entire pile of shell, no information was available as to what distances should separate piles of given size in order to ensure that the detona-

tion of one pile would not cause sympathetic detonation of neighboring piles. This question is of great importance in connection with the rearrangement of reserve stores of loaded shell in permanent storage depots, several temporary depots having been evacuated and their stocks moved to other depots. It is highly desirable that in the

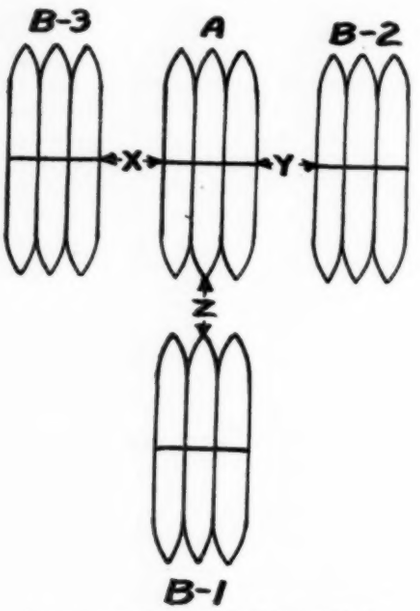


Fig. 2. Arrangement of Shell in Test No. 7

SIZE OF PILES:

A: 18 shell—3 shell in length; 3 shell in height
B1: 18 shell—3 shell in length; 3 shell in height
B2: 18 shell—3 shell in length; 3 shell in height
B3: 18 shell—3 shell in length; 3 shell in height

DISTANCES:

X: 4 inches. Y: 2 inches. Z: 2 inches.

interest of safety, these stocks of shell be stored in such manner as to ensure that an accidental explosion of one shell will not result in a sympathetic explosion of the entire contents of a magazine.

It was recognized that a part of the large number of shell which would be declared surplus could advantageously be used to carry out tests which it was hoped would furnish valuable information obtainable in no other manner, such information to be used in drawing up regulations for the arrangement of shell of various calibers in magazines, and also for the storage of ammunition in depots and dumps in time of war or other emergency conditions.

In April, 1922, a committee was appointed by the Chief of Ordnance to draw up a program and supervise the tests, which were to be carried out at the Aberdeen Proving Ground. It was realized that the entire program could not be prescribed in advance, but that it must be worked out step by step in order to conserve material and funds available. The following general procedure was first decided upon:

"(1) Conduct preliminary tests to select the type of shell with which the principal test to determine the quantity-distance relation will be made. The object of these preliminary tests is to determine the type of shell which represents the most unfavorable case, i. e., which causes sympathetic detonation through the greatest distance.

(2) With the type selected as a result of (1) determine the quantity-distance relation. Start with small quantities in the initiating pile and gradually increase the amounts until the curve can be plotted sufficiently to give the general shape. Then check the correctness of the curve with a quantity which represents the normal magazine pile.

(3) Check the accuracy of the higher points of the curve with shell of other representative calibers. Since the curve should represent the most unfavorable case it may be considered as checked if no detonation occurs with types which appear to be less sensitive as a result of (1)."

It was recognized that the quantity-distance relation would be affected by many factors, such as the caliber, wall thickness and shape of the projectiles, the kind, weight and condition of the explosive charge, the type of booster, the temperature, the efficiency of the initial detonation, the arrangement of projectiles in the piles, the arrangement of the initiating and secondary piles with respect to each other, the nature of the foundation on which the piles were placed (hard or soft ground, concrete, etc.).

In the preliminary tests referred to in (1), the following types of shell were used:

75 mm. H.E. shell, Mark I, loaded with cast TNT and fitted with Mark III boosters;
4.7-inch H.E. shell, loaded with cast TNT and fitted with Mark II boosters;
155 mm. H.E. shell, Mark IV, loaded with cast TNT and fitted with Mark III-A boosters;
8-inch H.E. shell, Mark I, loaded with 80/20 amatol (80 per cent ammonium nitrate and 20 per cent TNT) and fitted with Mark II boosters;
15-inch British howitzer shell, loaded with pressed TNT and TNT boosters.

None of these shell were provided with fuzes. With the first four types mentioned, the shell were arranged as follows:

Initial pile (hereafter referred to as the "A" pile).—Nine shell were piled on the ground in three tiers of three shell each, the shell in each tier in close contact with each other and tiers separated by one-inch wooden strips, as in actual storage.

Secondary pile (hereafter referred to as the "B" pile).—Two shell were placed one on top of the other, the lower one on the ground so that its long axis was in line with that of the middle shell of the bottom tier of the A pile,

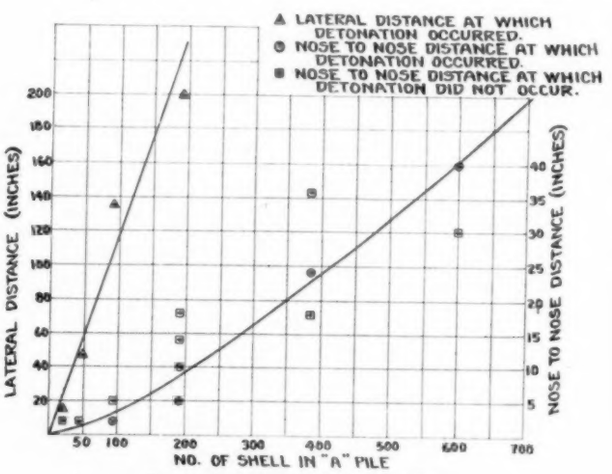


Fig. 3. Sympathetic Detonation Curve

the noses of the shell in the B pile facing those of the corresponding shell in the A pile.

A similar arrangement was used, with the 15-inch shell, except that the A pile consisted of six shell in two horizontal tiers of three shell each, and the B pile of only one shell directly opposite the middle shell of the bottom tier of the A pile.

The *A piles* were detonated by means of a No. 8 electric detonator inserted in the fuze cavity of the middle shell in the upper tier, a No. 6 blasting cap being placed beside the electric detonator and the cavity plugged with clay. The remaining shell in both piles were fitted with iron nose plugs to close the fuze cavity and protect the booster from fragments.

The distance separating the noses of the shell in the A and B piles was varied to determine the maximum gap through which detonation of the B pile would be accomplished.

It was found that with both the 75-millimeter and 8-inch shell the B piles detonated when the noses of the shell in the two piles were in immediate contact, but failed when the gap was two inches. Failures were obtained with the 4.7-inch, 155-millimeter, and 15-inch shell even with nose-to-nose contact. In every case where the above-mentioned means of initiation was employed complete detonation of all shell in the A pile resulted. In view of these results the 8-inch shell were selected as showing the greatest degree of sensitiveness and being best suited for use in determining the quantity-distance relation. Seventy-five-millimeter shell were not considered for the reason that they are stored in the form of assembled rounds, boxed.

It was originally planned to paint the shell in the A piles and B piles with distinctive colors so as to aid in the identification of fragments or unexploded shell. This method was promptly abandoned as it was found that no trace of paint was left on either the fragments or on whole unexploded shell, which were usually thrown for distances of several hundred feet. In all subsequent tests all of the shell in the B piles were marked with numbers indented by means of steel punches at intervals of a couple of inches over their entire surface. By this means whole shell and many of the recovered fragments could be identified. Shell fragments resulting from high order of detonation are characterized by sharp, jagged edges, while those resulting from a mere breaking up of a shell from the force of the blow delivered by the detonation of the A pile show a smoother fracture without the jagged edges.

In the series of tests conducted with the 8-inch shell, the piles were arranged to simulate as closely as possible the actual conditions in storage magazines, where the piles consist of double rows of shell with the bases of the shell in one row in contact with the bases of those in the adjacent row, the nose of every shell in each double pile being turned toward an aisle space. In each test detonation was initiated simultaneously in the two middle shell of the top tier—one in each of the two rows—by means of electric detonators connected in series.

The following shows the number and arrangement of shell in each set-up:

Test No.	Length of pile (shell)	Height of pile (shell)	Shell in half-pile	Shell per A or B pile
7	3	3	9	18
8	4	6	24	48
9	6	8	48	96
10	12	8	96	192
11	24	8	192	384

Beginning with test 9 the height of the piles (8 shell or about 6 feet) was the same as the height of the average piles of 8-inch shell as stored in the magazines.

In these tests it was also decided to determine the distance through which detonation would be transmitted *laterally* from one pile to another, as well as in the direction of the long axis of the shell. Accordingly additional B piles were placed *parallel* to and on both sides of the A pile, with a measured air gap between the piles. These were designated as B-2 and B-3 piles, the "nose-to-nose" pile as B-1. Figure 1 shows the set-up for one of the trials under test No. 7.

The following tabulation shows the results of this series of tests:

Test No.	No. of shell in A pile	Total weight of explosive in A pile *pounds*	Distance detonation transmitted laterally *inches*	Distance detonation transmitted "nose to nose." *inches*
6.-a	18	594	2	failed at 2
			4	
b	18	594	8	failed at 2
			12	
c	18	594	failed at 18	
			failed at 24	
d	18	594	14	
			16	
8.-a	48	1584	18	failed at 2
			24	
b	48	1584	28	
			32	
c	48	1584	36	
			40	
d	48	1584	failed at 50	
			failed at 60	
e	48	1584	failed at 43	
			47	
9.-a	96	3168	50	2
			75	
b	96	3168	100	failed at 5
			125	
c	96	3168	failed at 150	
			failed at 175	
d	96	3168	135	
10.-a	192	6336	failed at 150	5
			200	
b	192	6336		10
c	192	6336		failed at 14
				failed at 18
11.-a	384	12,672		failed at 18
				24
b	384	12,672		24
				failed at 36

The striking feature of these results is that detonation is transmitted laterally to much greater distances than in a "nose-to-nose" direction. This is to be expected when it is considered that the wave which causes the detonation must pass through the metal wall of the shell, and that the wall thickness is much greater at the nose than at the side of the shell. Furthermore the shape of the nose of the shell is such that the force of the shock meeting it is largely deflected.

Several discrepancies are noted. In test 8-e, detonation was transmitted laterally at 47 inches, but not at 43 inches; in test 10-a detonation occurred in a lateral direction at 200 inches, but not at 150 inches; in test 11-a detonation was transmitted from "nose-to-nose" at 24 inches, but not at 18 inches, the 24 inches result being confirmed in test 11-b. It has been suggested that these discrepancies may be accounted for by one shell in the B pile being actually penetrated by a fragment of shell from the A pile, thus causing detonation of that shell and consequently of the entire pile, even though the gap between the two piles was too great for the transmission of sympathetic detonation.

The curves shown in figure 2 represent graphically the results of the tests tabulated above.

The tests with laterally spaced piles were discontinued when transmission was found to occur at distances as great as 200 inches, since it is impracticable to make the corresponding aisles in a storage magazine greater than 5 or 6 feet. In the tests subsequent to test 10-a, the effect of barriers between the A pile and B piles placed laterally at a distance of 5 feet from the A pile was determined. These barriers consisted of piles of 75-millimeter ammunition boxes filled with sand. Barriers 13 inches and 26½ inches in thickness were tried. These were placed along the middle of the 5-foot gap, and both were found to be entirely effective in preventing detonation of the laterally placed piles, even though the barriers were completely demolished and the piles of shell broken up and scattered.

A complete report of tests 11-a and 11-b has been pub-

lished in this journal, Vol. 3, No. 15, pp. 180-2 (1922), giving many details which are not repeated here.

One additional test which may be added to the above series has been made, in which the A pile was a double row of 8-inch shell, 38 shell long and 8 shell high—a total of about 20,000 pounds of high explosive in the 608 shell. The "nose-to-nose" B piles were *single* rows of the same length and height, one at a distance of 30 inches and one at 40 inches. (As in Fig. 1.) For some unaccountable reason the pile at 40 inches detonated, while that at 30 inches did not. Laterally placed piles at a distance of 5 feet, protected by barriers as described above, failed to detonate. The crater resulting from the explosion measured 79 feet in diameter and 28 feet in depth. Space will not permit a description of the interesting details of this test, but one point of particular interest should be noted. The explosion was observed from a bomb-proof at a distance of 2,559 feet and four observers attempted to record by means of stop watches the time elapsing between the first visible sign of the explosion and the arrival of the air wave at the bomb-proof, it having been noted in previous tests that this air blast was felt before the sound was heard. These observations checked within 0.27 second, the average calculated velocity of the air wave being 364 meters per sec., as compared with the figure of 332 meters per sec. for the velocity of sound in air at 32 degrees Fahrenheit (the temperature of the air at the time of test was 26.5 degrees Fahrenheit, so that the correction for temperature can be neglected). This observation agrees with the results of other investigations already quoted showing that the air blast from an explosion travels for a considerable distance at a velocity greater than that of sound.

Brief mention may also be made of the fact that two tests made to determine whether a pile of shell detonated on a concrete foundation would transmit detonation through a greater gap than a similar pile detonated on the ground. A set-up similar to that employed in test No. 8 (see above), was arranged on a concrete foundation 8 inches thick and 15 feet square. On detonating the A pile of 48 shell, neither the B pile 48 inches distant laterally, nor the B pile 2 inches distant "nose-to-nose" were detonated. An identical result was obtained with a similar set-up on a concrete foundation placed within an abandoned house. In test No. 8 detonation resulted laterally at 47 inches and failed in the "nose-to-nose" direction at 2 inches. It is, therefore, apparent that the effect of a concrete floor of a magazine and the confinement offered by the walls and roof have no material effect on the transmission of sympathetic detonation.

As a part of this program additional tests will be made to check the accuracy of the curve shown in figure 2, and other tests to determine whether detonation transmitted from the initial pile to a second one will in turn propagate to additional piles spaced at equal distances.

It is hoped that a study of the complete data will lead to definite conclusions as to the best arrangement of shell in storage magazines. It has been established that by the division of a magazine into units separated by barriers of simple construction, a detonation can be confined to the shell in a single unit. Consideration must, however, be given to the fact that the use of any elaborate system of barriers will greatly reduce the storage capacity of the magazines.

For future construction the problem can best be solved by the use of small magazines of a cheap, light type, spaced at distances which will preclude the transmission of detonation from one to another.

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Rifle Barrel Steel

The steel ordinarily used for rifle barrels has one great defect: lack of resistance to corrosion. The magnitude of the results of this defect is little realized, but it has been brought home to individual owners of firearms when an especially prized barrel has been ruined by rust.

The number of barrels ruined in this manner is far greater than those lost through wear or erosion. Each year Springfield Armory builds a number of especially accurate guns known as "National Match Rifles." After use in the matches, many are returned to the Armory to be cleaned and repaired. Seldom have any of the barrels been used to an extent to cause loss of accuracy due to natural wear and erosion, but it is common to find 75 per cent or more of them so badly pitted by rust that they can no longer meet National Match requirements for accuracy, and many of them are a total loss and must be scrapped. As used in the heat-treated condition, the manganese steel, of which the Springfield Armory barrels are made, resists corrosion somewhat better than some of the softer types of steel which are used for the barrels of some firearms. But its action in this respect is not sufficient to provide any considerable degree of protection against rust.

A satisfactory noncorrosive alloy must possess considerable strength and toughness, but it should not be too costly or difficult to machine.

Several materials are available which meet the requirements as to freedom from atmospheric corrosion and as to tensile properties. Stainless Steel, Monel Metal, Delhi Steel, Nickel, Invar, and Cyclops No. 17 have been used by the Armory in experimental manufacture of rifle barrels. The difficulties encountered in machining were, however, so great that to date no barrels of the required standard of finish and dimensions of bore and chamber have been produced. With these materials the difficulties met in machining the bore were: excessive wear on the cutting edges of the tools, tearing the surface of the metal, and, to use a shop-term, "bugging," which means a building up on the tool of small patches of the metal being machined.

While success is not assured, the economic value of using noncorrosive metal in rifle barrels appears to be of sufficient importance to warrant continuation of experimental work with these materials. Work has been instituted by the Bureau of Standards, in conjunction with the Ordnance Department, on the solution of this problem.

Carton Loading

By

ARTHUR ADELMAN

CARTON loading is the name given to a method of loading high explosive into projectiles in which the explosive is first loaded into containers, usually paper, the filled containers being later slipped into the projectile cavity. These containers may be in one piece or made up in several sections, as is most convenient. They are made slightly smaller than the projectile cavity and are seated in some such substance as melted paraffin or preferably some cement with a slightly higher melting point than paraffin so that it remains set under the most adverse storage conditions.

Carton loading has been used abroad for many years, probably most extensively by the Germans. The original purpose is not definitely known, but from various reports examined it is believed that this method originated when picric acid was used as a bursting charge and that the main purpose was to eliminate the possible formation of sensitive salts by action of picric acid in contact with projectile walls and fuze parts. Other possible considerations are the elimination of friction between the bursting charge and the walls of the shell cavity which might cause premature explosion in the gun or upon impact of the projectile with armor plate, and the advantages of transporting and storing projectiles and explosive charges separately until such time as the use of the ammunition is imminent. The filled cartons can be effectively waterproofed by the simple process of dipping in melted paraffin, and can be assembled in the projectiles as required without the use of elaborate facilities.

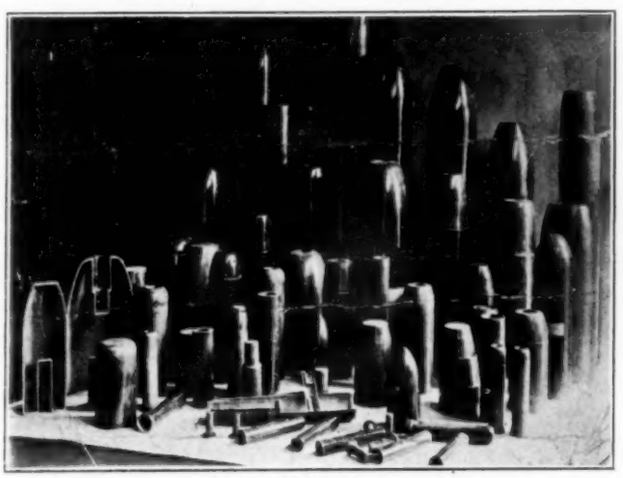

Fig. 1. Types of Cartons.

The first serious consideration of carton loading in this country appears to have been about 1911 at which time a number of reports were received indicating the formation of iron picrates in certain of the armor piercing projectiles in the coast defenses loaded with Explosive "D" and also in the smaller seacoast calibers such as 6-pdr. loaded with picric acid. While this matter was being investigated, information was received from one of the American manufacturers that carton loading was to be used in connection with one of its foreign orders and that preparatory to this work the foreign practice had been investigated. The advantages expected at that time from the use of carton loading were those already enumerated. The development was carried to the point of actually making firing and fragmentation tests with large caliber armor piercing projectiles and recommendation was made that carton loading be adopted for existing armor piercing projectiles. This was later found to be impracticable or difficult because projectile cavities had not been standardized. The drawings showed comparatively few different designs, but the cavities had not been gaged and difficulties were encountered in assembling cartons into projectiles at the Sandy Hook Proving Ground which had been prepared and fitted into sample projectiles at Frankford Arsenal. It was, therefore, decided not to attempt to use this method in projectiles already on hand. In the meantime, Grade I TNT had been adopted as standard filler for mobile projectiles. This explosive does not act on metals, thus one of the advantages of the carton method of loading was eliminated. Investigation of Explosive "D" and picric acid which had been removed from projectile cavities and tests made under severe conditions to actually produce iron picrates had indicated that there was no reason to fear that prematures would occur from the presence of the so-called iron picrates and that a carton was unnecessary from the standpoint of safety. However, development of this method was continued for some time and it was the intention to adopt this method for reserve ammunition for mobile artillery. Difficulties, however, arose in connection with the procurement of the paper carton, no facilities for the production being available. Experimental samples were obtained, but before any definite decision was reached the European War started and foreign governments began to install facilities for the loading of TNT in this country based on the casting method; that is, pouring molten explosive directly into the projectile. The practice in this country had been to press the granular TNT. The fact that these foreign governments, at least one of which had previously used carton loading, were apparently not attempting to continue that practice in war-time production influenced decision in this country so that the problem of development of carton loading lagged until work was finally dropped when the allotment was expended.

Upon our entry into the war, we adopted largely the explosives and methods of loading used by the British in their war program. These methods were not entirely satisfactory, the main defects being the presence of cavitation due to shrinkage of the mass of explosive in cooling and to exudation due to the grade of TNT used. These defects were pointed out in the article on "Ammunition Loading and Assembling," printed in the January-February 1922 number of ARMY ORDNANCE. In considering methods to overcome these defects and to obtain other advantages, the use of carton loading is being considered.

It is the purpose of this article to enumerate possible

difficulties and disadvantages rather than the advantages of carton loading on the theory that the difficulties require the most consideration since they must be solved before we can hope to reap any advantages that may exist. Before discussing the disadvantages, however, it is considered desirable to again enumerate some of the advantages. The original purpose, namely, that of preventing contact between the explosive and cavity wall of the projectile, no longer appears so important, although we still have much discussion as to the necessity for smoothness of cavity walls which would be definitely settled by the use of cartons. The main advantage must center around the ability to carry out the operations in the loading plant without having the projectiles actually at hand, permitting not only the major loading operations, but the transportation and storage of the explosive charges independently of the projectiles. The loading operations can proceed at the same time as the machining operations. The question of storage applies particularly to stocks of reserve ammunition. Components can be brought together somewhere in the direct line of supply and assembled with fairly simple facilities. It is the writer's opinion that the problem of exudation can be solved without the use of cartons and also that cartons will be found of little assistance in eliminating cavitation, except that it would facilitate inspection by the sectionalizing process.

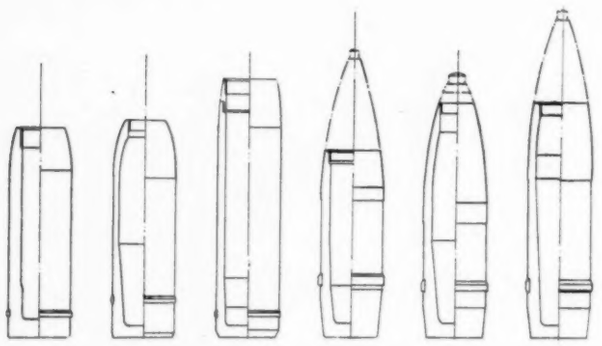

Fig. 2. Type Projectiles, 75-mm. and 77-mm.

Type	*Model*	*Wt. Lbs.*	*Exp. Lbs.*	*Exp. per cent.*
A. 77-mm. German	1896	15.	.34-.48	2.3-3.2
B. 75-mm. French	1900	12.4	1.75	14.1
C. 77-mm. German	1916	16.	2.	12.5
D. 77-mm. German	"C" Shell	12.9	1.2	9.2
E. 75-mm. French	1918	13.5	1.35	10.
F. 75-mm. U. S.	Exper.	15.	1.5	10.

The disadvantages of carton loading, in so far as the loading is concerned, are mainly centered around the problem of furnishing the cartons, loading the various sections and getting them to the assembly plants. The cartons are of course inexpensive and readily produced with proper facilities, nevertheless a vast number of different sizes and shapes would be required to meet all the requirements of types and sizes of projectiles, and it would be no small task to keep these parts flowing from the manufacturing plant to the loading plant and from the loading plant to the assembly plant in proper proportions. It would add to the number of parts to make up a complete round, and judged by the experience of the past war it is quite as liable to be the small apparently unimportant part which holds up the turning out of complete rounds as the more important parts. It appears significant that the Germans largely abandoned carton loading for the smaller calibers up to and including the 150-millimeter during the war. According to reports available, they used cartons 100 per cent for picric acid, to some extent for TNT and almost never for F. P. 60/40 (British amatol) or for dinitrobenzene. This applies to mobile artillery up to and including the 150 millimeter caliber. For seacoast projectiles carton loading appears to have been general as well as for larger mobile projectiles. Most of their projectiles were suited to carton loading through their latest 150 millimeter high explosive shell and some of their later gas shell apparently were not. Whether they found it impracticable to keep up 100 per cent carton loading, or merely not worth while, is not known, but the fact that with their years of pre-war experience they so largely abandoned it during the stress of war production appears worthy of careful consideration, in connection with any program of our own.

The main difficulty in the way of adoption of carton loading is in our projectile design. Carton loading requires the projectiles to be open at base or nose to the full diameter of the cavity; moreover, straight walls are desirable, since with taper walls no two sections can be alike, thus adding to the multiplicity of parts required. Taper walls also make it difficult to determine whether the carton is seated on the bottom, since it may ride on the taper leaving a void at the bottom.

To modify our shell design would require considerable experimental work and would discard most of our war-time experience on shell production. The types of shell in our service, most of which were laid down during the war, follow closely the French designs. They are of large capacity, manufactured in a single piece known as the monobloc type. The large capacity requires that the walls be thickest near the base and decrease toward the front end, so as to be somewhat proportional to the firing stresses. This gives a taper cavity, the largest diameter of which is near the bourrelet. As stated above, tapered walls are not the most suitable for carton loading. Separating the projectile at a point near the bourrelet is also open to question. To make the closing either at the rear or at the front as in the German designs would result in considerable reduction in bursting charge. The German designs were limited to about ten per cent or less, whereas the French designs provide for bursting charges usually not less than fifteen per cent, and considerably more for some howitzer shells.

There has been much discussion for many years as to the relative advantages and disadvantages as between large bursting charges or thick walls designed largely for fragmentation effect. At the outbreak of the war, countries other than France generally used the thick wall type, whereas the French designs provided for a maximum bursting charge. Conclusive results that will convince all concerned as to the relative effectiveness of the two types under service conditions can probably never be obtained. There is no doubt, however, that the trend during the entire war was toward the larger bursting charge. Our service adopted the French 75-millimeter and 155-millimeter designs. The French had two types of 155-millimeter, one having about fifteen per cent bursting charge and the other about twenty per cent. Decision was made early in the war that we would not attempt to produce the larger capacity type. However, instructions were received from abroad that this type was required in addition to the design having 15 per cent, and that our designs for other calibers, which we were preparing along more or less conservative lines, should be modified so as to provide a minimum bursting charge of 15 per cent in all cases. The British started the war with their thick wall types and were usually quite conservative on the question of making modifications in any matériel during the war. They, however, brought out designs of 8-inch and 9.2-inch shell each carrying about fifteen per cent of charge and the construction of which followed closely the French designs,

being the nosed-in monobloc type, whereas the early war designs were straight walls with screwed-in base plug. The Germans libewise made successive increases in bursting charge, particularly for their light field gun, following closely the French 75 millimeter type. Concerning the French 75-millimeter large capacity shell, General Rohne, a German officer who has written much on ordnance subjects in a post-war review of the lessons, stated as follows:

"The fundamental difference between the high explosive shells used with the German and French field guns, is that the German shell has thick walls and small bursting charge, while German shell obtains greater effect than the French shell by its fragments, the latter, however, by the tearing forces and noise of explosion causes as marked effect on the morale of the troops under fire, as if they had been the target for larger guns. Troops who have previously stood up well under shrapnel fire do not show up as well under French high explosive fire. The effect on the morale, the extent of which cannot be imagined, caused quite a surprise. The heavy bursting charge also produced considerable effect on the materiel."

This might be considered as an exaggerated statement expressing the opinion of an individual were it not for the fact that the German tendencies during the war were along lines consistent with that statement. The Germans started the war with the 77-millimeter shell, model 1896, carrying a bursting charge of .36 pound which was not sufficient to fill the cavity, the remaining part being filled with inert material. Soon, the model 1915 designs in which the bursting charge was increased to about .55 pound appeared. Later, this cavity was entirely filled with explosive making the bursting charge about .8 pound. In 1916, a design known as the "torpedo type," containing over two pounds of bursting charge was brought out. This shell carried a larger bursting charge than the French 75-millimeter, although about the same percentage, the German shell being heavier than the French. Late in the war the Germans brought out their stream-line shell in which the bursting charge was reduced. However, this appears to have been done from the standpoint of range and the shell was only used where extreme range was desired. The German stream-line shell follows very closely the percentage of bursting charge of the French stream-line shell, which also sacrifices some bursting charge to obtain greater range.

Concerning the large cavity torpedo shell of the Germans, a captured document from the German General Staff states as follows:

"The long high explosive shell is much more effective than any other shells for field guns, because of its heavy charge and large number of splinters made on exploding. The detonation is similar to that of the French melinite shell. . . ."

As stated above, there will always be a difference of opinion as between the merits of large bursting charge and maximum fragmentation effect. There is, however, no doubt that the tendency during the war was continually toward the larger bursting charge. This larger bursting charge effect was obtained with very little reduction in fragmentation effect, based on the weight of fragments. The ratio between weight of bursting charge and metal in a shell is such that a considerable percentage increase in the former can be made with only a small percentage reduction in the latter. It is possible that the small reduction in weight is more than compensated for by increased velocity of fragments. Based on the tendencies of the war, the Caliber Board prescribed that our new design of projectiles should be along the lines of maximum bursting charge capacity. For guns generally, maximum range was placed first with bursting charge to be the maximum consistent with range effect. For howitzers, the bursting charge was placed first. It, therefore, appears that whatever modifications are made in the design of shell to permit of improvement in loading, we are quite definitely committed to retain large capacity types.

Another point that must be considered is that of chemical filling. There is little doubt that for such filling the capacity should be the maximum possible. It is very desirable

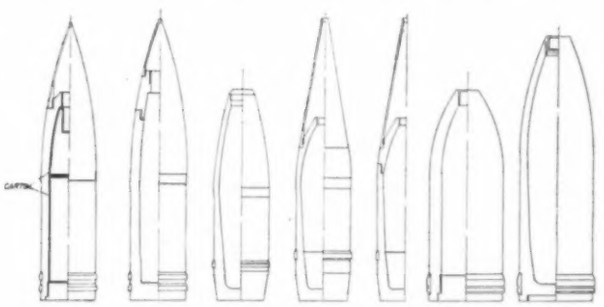

Fig. 3. Type Projectiles, 150-mm. to 8 inch.

Type	*Wt. Lbs.*	*Exp. Lbs.*	*Exp. per cent*
A. 150-mm. German	94.3	9.8	10.5
B. 150-mm. German	113.5	10.	9.
C. 155-mm. French	95.	15.	15.8
D. 155-mm. U. S. (Exper.)	95.	14.17	14.9
E. 155-mm. U. S. (Exper. Carton type)	95.	12.3	13.
F. 8-inch British	200.	19.5	9.7
G. 8-inch British	200.	34.	17.

that shell bodies for high explosive and for chemical filling should be as nearly identical as possible so that in case of sudden change in requirements shell bodies can be diverted from one type of loading to another, if practicable, and if not practicable, at least manufacture can be changed over from one type of body to the other with very slight modification.

Assuming then that we accept the large capacity shell, it will be necessary that we design it in two parts separating at a point near the bourrelet in order to adapt it to carton loading. This will make the shell body simple to manufacture, but will require the manufacture of a separate head from another forging. It is the opinion of some, that shell manufactured in two parts and screwed together will be easier to manufacture than the monobloc type. This opinion is based largely on difficulties encountered during the war with the nosing operation of our monobloc type. There is no doubt but that the nosing operation was a difficult one, and if we could simply eliminate that operation, it should undoubtedly be done. However, in order to eliminate the nosing operation, we must substitute other operations which may be fully as difficult. Concerning this point, it is interesting to note that the first shell we laid down following the outbreak of the war was a 3-inch caliber which had a screwed-in head. We were proceeding to lay down other calibers such as the 4.7-inch and 6-inch along similar lines and actually had such designs prepared on pencil drawings. At this time some of the manufacturers of foreign shells were called in to criticise the designs and a successful manufacturer of British 6-inch shell who had had experience on both the two-piece and the monobloc type recommended the latter type for production in large quantity where satisfactory equipment and methods could be worked out for performing the nosing operation. The designs were accordingly changed to follow as closely as practicable designs submitted by that manufacturer.

When we adopted the French 75-millimeter caliber, consideration was given to the two-piece design of 75-millimeter shell which the French had, but the French stated that this

was a discarded design. It is, of course, true that subsequently considerable difficulty was encountered in the nosing operation of our shell, and it is possible that the manufacturer who previously recommended the monobloc type might now recommend the two-piece type. This is, however, considered doubtful. While much difficulty was encountered in the nosing operation, this difficulty was to a considerable extent at least not inherent in the monobloc shell, but due to the particular design of the French shell which we adopted and to the fact that manufacturers were attempting to use methods and equipment in the manufacture of this French shell which had been developed for use with the British type which had a much shorter nose. This is clearly indicated by the following statement taken from the minutes of one of the meetings of the Associated Machiners of 6-8 Inch Shell held in June, 1918:

"Mr. Chairman, Mr..... is using the press method and he finds it advisable to profile inside after nosing in, and we use a hammer method. Now, we have refined our hammer method considerably since we first started in. We went to hammering in just the way we did on the British. We never had a rejection due to hammering on the British. But it is difficult with the French type, because that nose controls practically half the length of your shell. It is one of the most important operations there are on the shell, in my belief."

As soon as methods were adopted more applicable to the French type, less difficulty was encountered, although the French design with its long nose was always difficult to nose in satisfactorily. Our newer designs have taken into consideration this difficulty and have gone back to the blunter nose for the shell proper, the desired contour being obtained by the use of a false cap.

It would probably be necessary to produce any two-piece shell suitable for carton loading as a selective assembly proposition, particularly if joined together as far back as the bourrelet. The two parts must be machined after assembly to obtain proper fit at the joint and alignment of axes, and these parts must be kept together throughout the remaining machining operations and up to the final assembly after loading. Provision must also be made for screwing the heads up to the same position after loading that they occupied during the machining operation. Another difficulty in opening the shell near the bourrelet is that the setback stresses are fairly high at that point unless we thicken the body, which will, of course, reduce the bursting charge. This can probably be taken care of satisfactorily if we consider the shell body as completely heat treated. The first thing that manufacturers will request, however, is permission to anneal the extreme front end so as to facilitate the threading operation. It is doubtful whether this could be permitted and if not permitted great difficulty would be encountered in the threading operation.

It appears, therefore, that the question of carton loading revolves itself more into a question of shell design and production than into a simple question of loading. Careful study must first be made on the design of a shell suitable for carton loading. After such a design is prepared, if it should appear satisfactory from a theoretical standpoint, the question of relative ease of manufacture as compared with the present monobloc type should be taken up with experienced shell manufacturers. Assuming that the problem of the shell can be satisfactorily solved, we still have the problem as to the extent to which carton loading should be prescribed. The maximum would, of course, be 100 per cent for both peace and war-time; however, this is way beyond anything that has been done, and the fact that the Germans, to a considerable extent, abandoned carton loading of the smaller calibers should be considered. We might adopt carton loading 100 per cent for reserve stocks and abandon it for the smaller calibers during war-time, or we might adopt it for the larger calibers only, utilizing it for both reserve stocks and war-time production. Any of the schemes have certain disadvantages as well as advantages. Among the disadvantages are that the two-piece shell is not as good for present methods of loading as the monobloc type, due to the possibility of the explosive getting into the threaded joint. The use of cartons is liable to lead to a letdown in the smoothness of finish of the projectile walls, which may lead to difficulties if cartons are not maintained 100 per cent. This shell is likewise not suitable for chemical filling except by the use of metal containers. Metal containers for chemical fillings have their advantages, also a number of disadvantages among which are that the metal container will weigh a considerable amount, either making the chemical shell heavier than the high explosive or requiring that the chemical shell have the cavities machined to a larger diameter so as to compensate for the weight of the metal container. None of the semi-steel shell which are provided as substitutes for the standard types can be made suitable for carton loading without greatly adding to the machining cost, thus largely nullifying the advantages of this type of projectile. Separate loading facilities would, therefore, be required for the semi-steel shell.

Some of the difficulties enumerated in connection with the adoption of carton loading can be readily solved, others do not offer so ready a solution, but can probably be solved if the advantages to be gained justify. The first point which should be determined is whether the quality of carton loading is sufficiently superior to our present type to justify so radical a change in our established practice of both shell production and shell loading.

The Importance of the Chemical Industry to Ordnance

By

J. H. BURNS

IN the recent article by the Assistant Secretary of War on "The Chemical Industry" he states as follows: "In munitions production two great industries are primarily involved, the metals industry and the chemical industry. The metals industry gives us our guns and projectiles, and the chemical industry gives us our explosives and propellants. These, in general, constitute munitions."

Again he states: "There has been a popular use in the last few years of the term "Chemical Warfare" as pertaining solely to the use of poison gases and other gaseous materials. Practically all warfare is "chemical warfare." Chemistry is just as seriously involved in high explosive ammunition, in shrapnel, and in high explosive drop bombs as it is in poison gas. The manufacture of smokeless powder and high explosives, of which hundreds of millions of pounds are used in a year of modern warfare, are chemical processes involving chemically educated people, chemical facilities, and chemical principles."

I wonder if we fully appreciate the importance of his statement to the effect that 7½ cents of every dollar spent for the World War were for the chemicals in ammunition. If we look back to World War days and think of the chemical plants that were especially built by or for the Ordnance Department, we are apt to be staggered by the numbers, kinds, and sizes of such plants. And there were many more plants indirectly built. I am sorry that accurate data are not available to me in San Francisco and that I can only produce a partial list of the former plants from a somewhat hazy memory:

No.	Kind	Approximate cost
40	gas-stripping plants for production of toluol for T. N. T	$7,500,000
2	plants for recovery of toluol by cracking California oils	5,000,000
7	by-product coke-oven plants for recovery of ammonia and toluol, etc., from coal	50,000,000
1	plant for fixing air nitrogen by cyanamid process and making therefrom ammonium nitrate	70,000,000
1	plant for fixing air nitrogen by Haber or synthetic process and making therefrom ammonium nitrate	13,000,000
1	plant for fixing air nitrogen by Bücher process	2,500,000
2	smokeless-powder plants (Old Hickory and Nitro), including sulphuric and nitric acid plants, cotton purification, etc	150,000,000
1	plant for the double decomposition of ammonium sulphate and sodium nitrate with formation of ammonium nitrate	10,000,000
3	plants for manufacture of picric acid	10,000,000
3	plants for manufacture of T. N. T	10,000,000
1	plant for manufacture of T. N. A	3,000,000
1	plant for manufacture of tetryl	250,000
1	plant for manufacture of Explosive D	1,000,000
3	plants for loading high explosives into ammunition	50,000,000
	Total	$382,250,000

The initiation and general development of these plants required a comprehensive chemical knowledge of the general processes to be employed, the sites most favorable, the buildings and apparatus required, and the operating force and manufacturing materials necessary. The construction and operation of the plants required a tremendous force, a large percentage of which must have detailed chemical knowledge. Figures are not available to me, but it is probable that in excess of 200,000 workmen were employed in constructing these plants and that some 100,000 workmen would have been required to operate them. It is furthermore quite probable that some 5,000 chemists would have been necessary for satisfactory operation. They required colossal quantities of special chemical apparatus for their construction and operation.

Neither the proper chemical knowledge on the part of the directors and the constructing and operating forces nor the special chemical apparatus for construction and operation were easily forthcoming. There was a serious dearth of both. While the country managed to achieve almost unbelievable accomplishments, it has been a wonder to me why it was so successful. I believe that an analysis of our war efforts will show that our chemical success during the war was, in many of its principal phases, due to the all-important guiding information furnished from Europe. I am afraid we are too willing to believe that our success was due primarily to our own knowledge.

Many instances can be cited in which the controlling knowledge came from abroad either during the war or a short time before.

The cyanamid process of nitrogen fixation came from Europe.

The Haber or synthetic process of nitrogen fixation came from Europe.

The Bücher process of nitrogen fixation came from Europe.

The double decomposition of ammonium sulphate and sodium nitrate to form ammonium nitrate came from Europe.

The manufacture of ammonia from cyanamid and of nitric acid from ammonia came from Europe.

The use of amatol, or a combination of ammonium nitrate and T. N. T., to overcome the shortage of the high explosive T. N. T., came from Europe.

The method of loading amatol into ammunition came from Europe.

The water drying of powder, which had the effect of making powder available to the firing line some ten weeks

earlier than by the old air-drying method, came from Europe.

Mustard gas and practically all other gases came from Europe.

The basic principles of the gas mask came from Europe.

Even with this European assistance, which aided so greatly in the establishment of policies and in the design and construction of plants, it is believed that there would have been serious difficulty in satisfactorily operating all of our chemical plants because of the real scarcity of trained chemists. This scarcity was very pronounced in 1918, when only a part of our chemical plants were in operation. It is believed that the almost complete destruction in 1918 of one large loading plant, costing some $15,000,000, can be fairly charged to this shortage of chemical knowledge.

The experiences of the World War show more conclusively than it can be shown in any other way the importance of the chemical industry in modern warfare. As the Assistant Secretary of War indicates: It is practically equal to the metals industry in importance. I believe the same experiences likewise show that the United States is not nearly as well prepared in the development and utilization of the chemical industry as it is in the development and utilization of the metals industry.

The question arises: How can the country best prepare itself chemically? The all-important thing is to develop, at least to a parity with the other leading nations of the world, our chemical industry. If this industry does not exist we will have almost as much trouble in mobilizing it and utilizing it in time of war as we would have in mobilizing and utilizing unborn man power.

Many parts of our chemical industry are well developed, especially the heavy chemicals, such as sulphuric acid, nitric acid, etc. This development has been forced by the laws of economics—especially transportation charges on raw, intermediate, and finished materials. But the heavy chemicals field is so well established and is so comparatively simple that it does not require large numbers of trained chemists—trained chemists are, in fact, the backbone of the chemical industry. It is in their brains that the real knowledge exists and in which the new thoughts are born which are so necessary to properly harness and utilize the chemical forces of nature.

It is generally admitted that before the war Germany had developed her chemical industry to a greater extent than any other nation. Most of the important developments in chemistry were coming from her research chemists working in the well-established plants of Germany in which facilities for research were of prime importance. And it is generally recognized also that of all classes of her chemical endeavor, the dye industry was the most important. It covers a field which is practically limitless in extent and opens up to the chemist an almost infinite variety of chemical combinations. It is a field also that is very closely related to the chemicals at present used in war.

It is in this class of chemistry that the United States is at present behind the leading nations of the world and in which it is all important that she be on an equality with them. This class of chemistry—a large percentage of the cost of which is skilled labor—can only flourish in America when proprly protected against the much cheaper skilled labor of Europe.

In addition to building up the chemical industry it is equally important that the Ordnance Department thoroughly realize the part played by chemistry in modern warfare and train its personnel to understand and to be able to utilize to the fullest extent the chemical forces of nature. It must fully digest the statement: *The chemical industry is as important in munitions as the metals industry.*

Dyes and the National Defense

By

CHARLES K. WESTON

TO what extent has the American dye industry developed as a weapon of national defense and offense? How nearly could it meet the chemical needs of the Nation in a war emergency?

The American dye industry, born of the Nation's need when the World War shut off our supply of foreign colors has come into its own commercially. The French occupation of the Ruhr, in which centers what was at the beginning of the war the only source of dye supply in the world, has caused hardly a ripple of excitement among the consumers of dyes. Commercially America is self-sufficient, except for a few specialties, and has products to spare. She is not affected by this economic blockade growing out of the European situation.

Have we at the same time developed materials, plants, and personnel which make the dye establishments such potential arsenals as those from which the Germans maintained their war supplies during all the years of the great war.

In all the literature and speeches pointing out the need of such an industry in this country, stress was laid on the military possibilities and importance of dye plants. The one great lesson the war taught is that chemicals—not merely poison gases—will play an ever-increasingly important part in future warfare, and the question which now confronts us is: Are we prepared?

In view of what we know about the military value of Germany's dye plants, it goes almost without saying that the great commercial development of the industry in this country has automatically carried along with it the development of untold military strength. The many plants now in practical everyday manufacture of dyes are without question arsenals of the greatest value to the Nation.

Even the layman of today knows that he who makes dyes is fully equipped to make explosives; that the processes by which these two products are manufactured are identical to a certain point and that branching off from this point, the same materials become on the one hand explosives and on the other commercial colors. It is like the letter Y, with the coal tar at its base, explosives at one of the upper terminals and dyes at the other. The same plant, the same equipment, the same personnel can supply either. The laboratory research work which develops one, develops the other.

Some interesting illustrations are:

The largest dye used in America at the present time is Sulfur Black. Benzol is chlorinated by chlorine manufacturers and sold to the dye plants. Chlorbenzol is converted by nitration into a product known as dinitrochlorbenzol which by a simple operation is transformed into dinitrophenol. Dinitrophenol is an intermediate material for sulfur black or for picric acid. If the dinitrophenol is treated with sodium polysulfide it produces the black which is used in large quantities for the dyeing of cotton hosiery. If it is nitrated it is converted into the high explosive, picric acid. Immediately after the declaration of war it would be possible to begin in our dye plants the manufacture of picric acid.

During the war diphenylamine was used in very large quantities as a stabilizer of smokeless powder. Diphenylamine is now manufactured and consumed in considerable quantities in the manufacture of yellow dyes used for the dyeing of paper and silk. If war should be declared, plants could begin the manufacture of smokeless powder and the quantity would not be restricted as a result of any shortage of diphenylamine as a stabilizer.

Plants are available today manufacturing dinitrotoluol, an intermediate which is used in large quantities in the dye business. The plants manufacturing this product could be expended immediately for the manufacture of trinitrotoluol.

Aniline is converted by the action of methyl alcohol in the presence of a small amount of acid to dimethylaniline. This product is used in very large quantities in the manufacture of an important group of dyestuffs. By nitration it is converted into tetryl, an explosive manufactured in considerable quantity during the war.

It is possible now to speak in the past tense of the things which we discussed a few years ago in the future tense.

During the war, when we had no coal-tar chemical industry worthy of the name and when we first realized our lack, our first great need was found to be a trained personnel. Chemists were withdrawn from the camps and detailed to help meet the war emergency. Instructors were called from their chairs in the colleges and universities and set to the task of developing manufacturing processes with the result that months of most valuable time were lost. Today the dye factories of the country are well equipped with men trained by years of experience in practical work. The educational equipment secured by enlarged classes in our institutions of learning has been supplemented by practical work in the factories and these men are now ready at a moment's notice to be mobilized for any war need. Their accumulated experience in a firmly established enterprise is possibly one of the most valuable assets which these dye plants have to offer to their country.

Not only are these men equipped to do the actual work, but they are ready to act as directing heads for the less skilled personnel which would necessarily be called upon to man hastily expanded plants if the need came.

With such men in command a repetition of the fatal experiences of the recent war will be avoided. Men trained in the handling of chemicals know what to expect from these chemicals and knowing this, they will be able to safeguard lives and property which were sacrificed through ignorance in the hurry and bustle of the recent war years. There is a wealth of such material available now. The men who came out of the colleges and laboratories with fine theoretical equipment and have gone into the manufacturing plants will be able to command and train a great army of nontechnical workers.

In the research sections in the great laboratories established at the commercial plants and in the colleges and universities of the Nation, work of the highest value is being done. Germany's chemical war material all came out of her dye factories. The high explosives were developed there and her gases, by the use of which she startled the world, virtually all were in daily use in the manufacture of dyes. They had all been discovered and developed as a part of the daily business of the plants.

Phosgene gas used by the Germans in the great surprise attack against the Canadians at Ypres was developed in a German dye factory. America, when she went into the war, established a large factory at Edgewood Arsenal and turned out great quantities of this gas, there being no American dye plants from which it could be obtained. In the dye plants which have been established since then, prosgene is used largely in the manufacture of both dyes and pharmaceuticals.

Mustard gas, the most generally used on the battlefield, was developed through the dye factories in both Germany and Great Britain. The same dye plants could, with unimportant changes, turn their entire energies overnight into the manufacture of this war weapon.

The same statement applies to numberless other chemicals useful in battle, so that one speaks with authority when he makes the statement that the mobilization of America's coal-tar chemical industry as a weapon of war could be accomplished in days at the utmost.

The development of raw materials entering into the manufacture of modern high explosives is of the utmost importance, and this development in our country is growing every moment because of the increased demand for these supplies made by our dye factories. Until recently millions of pounds of coal tar—the base of synthetic dyes and most high explosives—went up in smoke from our coke ovens. The country had little use for it. Today with the demand from the dye plants, this basic raw material is being saved to the Nation. The dye plants are keeping hundreds of raw material manufacturers at work, and plants employing many thousands of workers are being kept busy on fundamental raw materials.

A recent survey of American colleges and universities showed that as a development of the dye industry, the number of students of chemistry had more than tripled since the war. This was attributed to the opportunities for future employment of these students offered in the dye plants of the country. This of itself is of great importance to the safety of the Nation.

The availability of chemical literature, 90 per cent of which came from foreign sources before the war, is of equal importance. Our research chemists and industrial leaders are filling our technical libraries with material of great value.

It is not possible even now to give statistics on the amount of money invested, the extent of the plants, or the number of workers employed, because this industry is just passing out of its formative stage. Equipment and processes developed experimentally are abandoned after a short time to give way to better equipment and newer processes. The development has been so rapid that many millions of dollars spent in experimentation and now charged against the upbuilding of the plants should be marked off if one sought to give the present-day value of the investment. The one thing that has not been subject to waste has been the man power developed in this experimentation. Each step, even though it were commercially without value, has developed men, and after all the well-equipped human factor is the most valuable in an emergency.

We have before us every evidence that the dye industry is well established technically. We have every reason to believe that its value as a means of national defense is great.

Brigadier General George W. Burr

THE ARMY ORDNANCE ASSOCIATION announces with regret the death, on March 4, 1923, of one of its most distinguished members, Brigadier General George W. Burr, U. S. A., Assistant to the Chief of Ordnance.

General Burr was born in Illinois, December 3, 1865, and was appointed to the United States Military Academy from Missouri, June 15, 1884. He was graduated number four in the class of 1888. He was assigned to duty as second lieutenant, First Artillery, June 11, 1888, and served in garrison with that regiment at the Presidio of San Francisco for several years. In 1891, he was transferred to Fort Hamilton, New York Harbor, and later served as Professor of Military Science and Tactics at the Agricultural and Mechanical College of Mississippi until July 7, 1893. He was appointed first lieutenant in the Ordnance Department January 10, 1893, and served at the Allegheny Arsenal, Rock Island Arsenal, Watervliet Arsenal, and Sandy Hook Proving Ground until September, 1902. He was promoted to captain, Ordnance Department, April 7, 1899.

Brigadier General George W. Burr

During these years he was actively connected with the design, development and tests which led to the adoption of the new type of Field Artillery matériel, the 3-inch long-recoil gun carriage, Model of 1902, and he developed its manufacture while stationed at the Rock Island Arsenal. This matériel had been in service for a number of years as the standard Field Artillery matériel of the Army, and so remained until the outbreak of the recent war.

Captain Burr was promoted Major of Ordnance June 25, 1906. He served as Commanding Officer of the Manila Arsenal and as Chief of Ordnance Officer, Philippine Division, from 1907 to 1910, being in charge of the Philippine Armament District as well as a member of the Fortifications Board, Philippine Islands, during this period. Upon completion of his tour of foreign service, he was assigned to duty as Commanding Officer of the Augusta Arsenal, Augusta, Ga., in 1910. He was promoted to Lieutenant-Colonel, Ordnance Department in that year, and was ordered to duty as Commanding Officer of the Rock Island Arsenal in 1911, where he remained in command until February, 1918. He was promoted Colonel, Ordnance Department, in 1916.

When war was declared in 1917, Colonel Burr was Commanding Officer of the Rock Island Arsenal. He had anticipated the necessity for the large expansion of that Arsenal, and had been very active in securing the necessary appropriations for new construction so that, upon the outbreak of war, there was already in process and well advanced a Field Artillery ammunition factory, a Field Artillery vehicle factory, and a large storage plant, all of permanent type. He had also negotiated the purchase of approximately 15,000 acres of ground at Savanna, Ill., and had initiated the construction of the Savanna Proving Ground. These construction projects involved the expenditure of approximately $12,000,000. During his administration of the Rock Island Arsenal in the early months of the war, the working force at that establishment was increased from about 2,500 employees to approximately 13,000. As this Ordnance establishment was the largest in the United States for the manufacture and issue of Ordnance matériel, being practically the only source of supply for personal and horse equipment and mobile artillery, his work there was an important factor in the expeditious outfitting of our troops.

In February, 1918, he was sent abroad to join the American Expeditionary Forces, and assigned to duty as Chief Ordnance Officer in England, with station in London, on the staff of Major General Biddle. During this tour of duty, which lasted seven months, he represented the Ordnance Department in large purchases from the British Government of heavy artillery, artillery ammunition, and other supplies so vital to the success of our Expeditionary Forces. This duty required many visits to the larger manufacturing plants in England and Scotland, and a thorough knowledge of and familiarity with their methods and capacities. His energetic prosecution of these procurement activities unquestionably contributed very materially to the successful operations of our combatant divisions on the Western Front. While on this duty, he was appointed Brigadier General, Ordnance Department, August 8, 1918.

In October, 1918, he was recalled from abroad to take over the Engineering Division of the Ordnance Department in Washington, and had been on that duty only a short time when the Armistice was signed. In December, 1918, he was detailed for duty on the General Staff, and appointed Assistant Director of Purchase, Storage and Traffic, and upon the retirement of Major General George W. Goethals to civil life, General Burr succeeded him as Assistant Chief

of Staff, Director of Purchase, Storage and Traffic, with the rank of Major General, March 5, 1919. He continued in that position until relieved at his own request September 1, 1920.

General Burr's broad experience during the preceding ten years in connection with the procurement and manufacture of army supplies on a large scale had admirably fitted him for the tremendous task of carrying out the demobilization work in so far as it affected supply, transportation, settlement of war contracts, disposition of stores, etc. In this capacity he was a member of the War Department Claims Board from its establishment, February 20, 1919, until August 31, 1920. He was also the War Department member of the Interdepartmental Board of the Council of National Defense, from November 1, 1919, the date of its establishment, until he relinquished his duties as Assistant Chief of Staff on August 31, 1920.

Upon his relief from duty as Assistant Chief of Staff and Director of Purchase, Storage and Traffic Division of the General Staff, General Burr was sent abroad on a special mission as the personal representative of the Secretary of War to negotiate final settlement of all outstanding War Department business with certain foreign governments. He was abroad on this mission from September 7 to December 8, 1920, and negotiated the important Burr-Niemeyer Agreement by which all outstanding United States War Department business with the English Government was finally settled. He also successfully negotiated certain settlements with the Grand Duchy of Luxembourg.

He was appointed Brigadier General, Assistant to the Chief of Ordnance, for a period of four years in 1920, and upon his return to the United States in December was assigned to duty in Washington as Chief of Field Service of the Ordnance Department, charged with all questions of storage, supply, and maintenance of Ordnance matériel, in which capacity he was serving at the time of his death.

General Burr was awarded the Distinguished Service Medal for his exceptionally meritorious and conspicuous service in connection with the demobilization of supply and industry consequent upon the termination of the war. He was also awarded the decoration of Companion of the Bath by the English Government for his services in England and France during the World War.

General Burr is survived by his widow, who, before her marriage, was Miss Lydia Kent, of Sedalia, Mo., to whom he was married on September 7, 1892. He was a member of the Army and Navy, Racquet, and Chevy Chase Clubs, of Washington, D. C.

In his untimely death the Ordnance Department and the Army have lost an exceptionally able and efficient officer, a man of kindly qualities and of broad attainments.

Tetryl and Other Booster Charges

By

FRED OLSEN

TETRYL is the explosive which comprises the booster charge, and which is, therefore, an essential element in almost every round of ammunition. The booster charge is a most important member of the train of explosives which almost invariably consists of an initiating agent contained in a primer cap, a delay element, a detonator, a booster charge, and finally a bursting charge.

The initial impulse which starts the functioning of this train of explosives is given to a primer or cap usually by means of a blow, either from the impact of the projectile against some body, or by the operation of some timing device or fuze, which at the proper instant causes the release of the firing pin.

A spit of flame from the cap effects the detonation of a charge of mercury fulminate contained in the detonator either directly or through the medium of a charge of "delay" powder. It is then the duty of the tetryl to magnify the waves of detonation initiated by the mercury fulminate until the impulse is great enough to bring about the detonation of the main bursting charge which is usually a relatively insensitive explosive.

While the booster cannot be said to be of greater importance than any of the other members of the train of explosives, it is obviously necessary that it must be certain to perform its function.

Although tetryl is usually considered one of the very recent developments in explosives, it has been known for forty years. It was first prepared by Mertens in 1877, who described the substance accurately and gave the method for its preparation. However, it was not until 1883 that Romburg working in the same laboratory at Leyden was able to establish the identity of the substance which Merten had prepared, as trinitrophenylmethylnitramine, or tetryl as it is now known.

Tetryl has been employed by several nations as a booster explosive, and during the early stages of the World War Great Britain turned to the use of tetryl giving it the designation "C. E.". On the entry of the United States into war, the British practice, which had been found to be very satisfactory, was adopted and tetryl was substituted in our boosters in place of picric acid.*

Unfortunately the production of tetryl in the United States never exceeded about 60 per cent of the estimated requirements for a booster explosive. The practice was, therefore, established of substituting grade 1 TNT for part of the tetryl in the booster charge. This, however, has been shown to be unsatisfactory, inasmuch as a number of incomplete detonations have been obtained with standard types of fuzes and boosters loaded in this manner, so that the present practice is to use tetryl alone.

Only two firms were engaged in the manufacture of tetryl in the United States during the war, i. e., the E. I. du Pont de Nemours Company, at their plant at Deepwater Point, New Jersey, and the Bethlehem Steel Company at their plant at New Castle, Delaware.

The methods of manufacture adopted by these two companies differ in many respects, and the available capacity of the Bethlehem Steel Company's plant at New Castle was so small that the quantities produced for the United States formed only a very small fraction of the actual requirements. The capacity of the du Pont plant was considerably greater, but the combined activities of these two

* Prior to this date picric acid had been superseded by TNT which in turn was superseded by tetryl as stated.—ED.

plants were insufficient to meet World War requirements for a booster explosive.

Although sufficient material is on hand to meet the immediate needs of the service, there is no present production of tetryl, nor do there exist any facilities for its manufacture. These conditions are obviously very unsatisfactory.

A project is, however, actively underway at Picatinny Arsenal which will provide facilities for manufacturing tetryl on a small scale and, what is still more important, for investigating various improvements in the methods of manufacture.

As close contact as possible is being preserved with certain firms as are engaged in the manufacture of chemicals, which are in any way analogous to tetryl, or to the materials entering into the manufacture of the same. Information of much value will undoubtedly be accumulated from the cooperation between these companies and the Ordnance Department, and it is confidently expected that in time of emergency an adequate part of the chemical industries will be sufficiently mobilized so that no deficiencies either in quantity or quality of this important explosive are likely to be experienced.

Whereas it is true that several manufacturing difficulties were experienced during the war, which were not entirely overcome, it is believed that the post-war investigations, which have been conducted at Picatinny Arsenal have resulted in overcoming most of these obstacles. A much clearer knowledge has been obtained of the mechanism of the various complicated chemical reactions involved, so that it will be possible to more intelligently regulate these processes and avoid those side reactions which give rise to undesirable products. The production of tetryl ought therefore to be facilitated and even the properties of the explosive be improved, or at least be standardized so that a uniform behavior can be secured.

From a careful consideration of the results of numerous and periodic tests on samples of tetryl, which have been in storage and under surveillance since 1918, and also from the results of more elaborate tests carried out on batches experimentally prepared, it can be concluded that there is absolutely no evidence which would lead one to suppose that good tetryl—that is to say, material which is at least as good as that prescribed by present specifications—will not function perfectly one hundred times out of one hundred, even after indefinite storage.

Tetryl is sufficiently insensitive to shock, so that when loaded at the correct density, it can be used as a component of armor piercing projectiles, and it will satisfactorily withstand the shock of setforward when the projectile penetrates caliber plate. On the other hand, it is sufficiently sensitive to detonate upon receiving the initial detonating waves produced by the mercury fulminate in the detonator. In fact complete detonation of tetryl is secured with a smaller amount of mercury fulminate than is needed for most explosives which have been suggested as substitutes for tetryl. It is non-corrosive and consequently has no action on the metals with which it comes in contact. This is especially important, as otherwise the metal parts might be seriously damaged, or sensitive metallic salts might be formed, which could possibly result in premature explosions either during the initial stages of the flight of the projectile or before the complete penetration of the armor plate.

Another important property which tetryl possesses to a preeminent degree is non-hygroscopicity. After tetryl has been dried, the amount of moisture which it will absorb, even in very damp atmospheres, is so small that the functioning of the explosive is not affected.

Finally, the primary raw materials, which enter into the manufacture of tetryl are substances which are readily obtainable in the United States at all times. These are benzene, wood alcohol, sulphuric acid, and nitric acid. This last statement is made with the proviso that suitable plants for converting the nitrogen of the atmosphere into nitric acid, such as exist and are planned at Muscle Shoals, will be maintained and developed.

In view of the shortage which was experienced during the war, numerous attempts were made to find suitable substitutes for tetryl, and recently consideration has been given to the merits of several new explosives. Among the materials which have been investigated are TNA, picric acid, hexil, cyclonite, TNB, nitro derivatives of the phenyl guanidines, and cyanuric triazide. Some of these substances, as for example, the last two mentioned, have only been recently discovered. In spite of the imposing array and wide variety of the substances examined, tetryl still ranks first, although one or two of these substances may after further experimentation be shown to possess certain advantages over tetryl. At least it seems assured that some of these materials may be regarded as reserve booster explosives, should occasion warrant their use either as substitutes for tetryl, or as supplementing our stocks of booster explosive.

TNA or tetranitroaniline is the only material which has been authorized by the Ordnance Department as a substitute for tetryl. It has the striking advantage that it is the most powerful of the true nitro explosives. No instance has been known in which this material failed to perform in a satisfactory manner as a booster explosive. However, it has the disadvantage at the present time that it is more difficult to manufacture in a form which will meet the exacting requirements of the Ordnance Department than tetryl.

Although criticism has frequently been made against the stability of this explosive, it has never been demonstrated that TNA is actually chemically unstable. The tests on which the criticisms were based comprised the 65.5 degrees C. test with potassium iodide paper. While it must be admitted that TNA caused a discoloration of the KI paper in a shorter time than certain other explosives, it is by no means certain that this test is applicable to TNA, or that the discoloration of the test paper really is any indication of chemical instability.

Samples of TNA have been held under surveillance for five years, and up to the present there is no indication of chemical deterioration and the explosive properties have been maintained in high order.

Picric acid can hardly be considered a substitute for tetryl; indeed, the reverse is true. Picric acid first held the field as a booster explosive, but was displaced by the more powerful tetryl. Prior to the war the United States depended to a great extent on pressed picric acid as a booster charge, and although this explosive is slightly more insensitive than tetryl in picking up the waves of detonation produced by the mercury fulminate, nevertheless it is by no means certain that the good qualities of picric acid are not sufficiently great to warrant its reconsideration, at least as a reserve booster explosive. Picric acid is also employed as a booster explosive by France. Italian ammunition frequently exhibits a complicated booster system involving a primary booster, which is usually picric acid, and auxiliary booster explosives which may be pressed or cast TNT, or even fine granules of colloided nitroglycerine and guncotton. Germany also employs picric acid, but not exclusively, since tetryl is used in important quantities. It is thus not entirely certain that the substitution of tetryl for picric acid was a very logical one, since picric acid is cheap, easy to manufacture, and can readily be made of guaranteed purity. As remarked above the objections to picric acid are mainly due

to its supposed ability to form sensitive metallic picrates when in contact with the metal of the booster or fuze seat liner. This has not been fully demonstrated, but even if it should be proven conclusively, it is believed that this objection can be overcome.

Hexil, or hexanitrodiphenylamine, is also a cheap explosive which has given some very remarkable fragmentation results, but is apparently very erratic in its behavior. Thus far suitable means have not been worked out for controlling the physical form of the product, and it would seem that the defects encountered do not give promise of being readily overcome.

Cyclonite is a new explosive whose chemical name is cyclotrimethylenetrinitramine. It is produced by nitrating hexamethylenetetramine which, in turn, is a condensation product of formaldehyde and ammonia. It has about the same strength and brisance as tetryl, and a thorough test is now being made to determine its properties in detail.

TNB, another explosive of this class, is, chemically, trinitrobenzene. Much was expected of this explosive, which is known to be more powerful, more evenly balanced as to its chemical composition than TNT, and presumably would consist of molecules having marked symmetry, and hence good chemical stability. It was found, however, to possess a number of unsatisfactory characteristics. It does not press very well, since the pellets are invariably more brittle than those of tetryl, and, from a series of fragmentation results, it was found to be less efficient than tetryl. It has also an irritating action on the skin of the operators working with it.

Of the nitro derivatives of phenyl guanidine, only a very limited study of hexanitrodiphenyl guanidine has been made, and although the explosive properties of this substance appear to be comparable with those of tetryl, it will be no cheaper to produce, nor does its manufacture promise to be simpler in any way.

Cyanuric triazide has been found to be altogether too dangerous to handle for consideration as a satisfactory product.

Present opinion is that the best interests of the Ordnance Department will be served by concentrating research efforts on improving the methods of manufacturing tetryl. Considerable progress has been made during the last few months at Picatinny Arsenal along these lines, and it is confidently anticipated that a satisfactory solution of the various difficulties will be forthcoming.

In order to point out more clearly the nature of the changes which are being made, the manufacturing processes considered best at the present time will be briefly sketched.

Aniline, which is produced by treating benzene with mixed sulphuric and nitric acids, and reducing the resulting nitrobenzene with finely divided iron and hydrochloric acid, must first be converted into dimethylaniline. This is a difficult and expensive operation, as it involves the treatment in enameled autoclaves of aniline and methyl alcohol in the presence of sulphuric acid and traces of iodine, which serve as a catalyst. The main difficulty with this part of the process lies in the ease with which leaks are developed in the enameled autoclaves, especially under high temperatures, high pressures, and the presence of acids. Dimethylaniline, after suitable purification by distillation, is treated with sixteen times its weight of sulphuric acid for about one-half hour, the temperature being maintained at about 30 degrees C. No time is lost in adding this sulphuric acid solution of dimethylaniline sulphate to nitric acid of about 80 per cent concentration, the temperature throughout the nitration period being 65 to 70 degrees C. The crystals of tetryl are separated from the spent acid by filtration, drowned in a large volume of water, and boiled for about two hours. The crystals are then ground while still wet until they pass through a 150-mesh screen, after which the tetryl is given two five-hour boils in fresh water.

It has apparently been demonstrated that if the dimethylaniline sulphate is allowed to remain in storage some changes occur which are not understood, and which result in the formation of various nitro bodies during nitration. Material has been produced in this way which can be removed from the finished tetryl by treatment with benzene. Tetryl is completely soluble in benzene, but these nitro derivatives are quite insoluble, and when thus separated are found to comprise a brisant explosive melting at about 220 degrees C.

From its nitrogen content this material is thought to be incompletely nitrated tetryl (2.4 dinitrophenylmethylnitramine). The melting point for this substance is given by Mertens as 220-225 degrees C., with decomposition, and the same authority also states that the substance is insoluble in toluene (and hence in benzene also). It is curious if the prolonged treatment with sulphuric acid, as suggested above, is responsible for a retardation of the nitrating reaction. However, the explanation may be that with a very short time elapsing between the addition of the sulphuric acid and the beginning of the nitration, there results only the formation of dimethylaniline sulphate; whereas with a prolonged action between the sulphuric acid and the dimethylaniline, it is conceivable that a true sulphonic acid of dimethylaniline may be formed, which considerably hinders the introduction of the nitro groups.

Further, it has been shown to be absolutely necessary to boil the tetryl before grinding, in fact the gummy nature of the material renders it almost impossible to grind if the boiling treatment is omitted. This boiling evidently serves to effect the hydrolysis of the various organic impurities.

The conditions which exist in the nitrating bath toward the end of the process are such as favor the formation of metanitro derivatives of dimethylaniline. These metanitro compounds are somewhat readily decomposed by boiling water. However, even though the subsequent boiling treatment be given after grinding, any deviation which has been practiced in the method of nitration, such as change of temperature or concentration of nitric acid will be readily revealed by the difficulty with which the amount of occluded acidity or other impurities is reduced. By careful adherence to details it has been possible to prepare batches of tetryl having a melting point of 129 degrees C. or greater, in contrast with 128.5 required by British specifications, and 128.0 required by the Ordnance specifications during the war.

It should be noted that the method employed for purification comprises only boiling with water before and after grinding. This is by no means the usual procedure abroad, where purification by recrystallization is adopted almost everywhere. The crude nitration product after preliminary boiling is either recrystallized from 95 per cent nitric acid or from acetone, the latter being considered the better method. Both of these methods are viewed with disfavor in this country owing to the difficulty with which the nitric acid, which has been used for recrystallization is separated from the tetryl, and in the case of acetone purification on account of the expense involved in the manufacture, use, and elaborate acetone recovery system required. It is anticipated that subsequent tests will show that the technic of nitration and water purification has been developed to such a point that recrystallization is quite unnecessary.

The program of investigations now under way at Picatinny Arsenal comprises a small amount of additional work on the processes given above, special attention being given

to nitrating the dimethylaniline in several stages rather than in one stage as is commonly practiced. The significance of this may perhaps best be indicated by pointing out that although tetryl contains only one methyl group attached to the benzene nucleus, it has always been fund more convenient to start with *di*methylaniline, rather than *mono*-methylaniline.

The first stages of the nitration of dimethylaniline involve the addition of nitro groups to the benzene nucleus. When this has taken place one of the methyl groups (i. e., CH_3 group) must be removed by oxidation with nitric acid, the carbon being oxidized to carbon dioxide and the hydrogen to water. This unfortunately consumes a very large quantity of nitric acid and at the same time produces a considerable evolution of gas, together with the liberation of large quantities of heat. Under the present system in which dimethylaniline is added in very small quantities to a large mass of nitric acid, conditions favor the immediate nitration and oxidation of the dimethylaniline practically as soon as it strikes the main body of the charge. In this manner the oxidation, with its attending gas evolution and liberation of heat, is spread out over the entire reaction.

Consideration has been given to reversing the nitration procedure by adding to the complete charge of dimethylaniline dissolved in sulphuric acid, sufficient nitric acid to effect the introduction of only one nitro group into the benzene nucleus, maintaining the correct temperature and concentration conditions to accomplish this reaction, and following this by subsequent additions of nitric acid at higher temperatures and possibly higher concentrations, until three nitro groups have been introduced into the ring. The next step was then to substitute the final nitro group for one of the methyl groups by oxidizing the latter. The nitrating apparatus was provided with ample means for temperature regulation during this stage; in order to prevent the oxidation reaction from becoming too violent. By this means it was hoped that tetryl could be produced with a minimum number of side reactions, which latter cause the formation of undesirable impurities in the final product. All attempts along these lines, however, have met with failure. It is apparently necessary to maintain very definite ratios between the amounts of sulphuric acid, nitric acid, and water, otherwise metanitro compounds are produced.

Even a casual examination of the facts would appear to indicate the desirability of substituting monomethylaniline for dimethylaniline in order to eliminate the wasteful oxidation of one of the methyl groups of dimethylaniline. The use of monomethylaniline has been attempted on several occasions without success. It is now planned, however, to determine whether the multistage nitration process, suggested above, will not prove to be the solution of the difficulties previously experienced.

An entirely different line of attack has been followed by Great Britain, France, and the United States in which the starting material was not dimethylaniline, but dinitrochlorbenzene. This latter substance is very easily obtainable, and although it is very unpleasant to handle, good tetryl can be produced from it at a reasonable cost. The process comprises treating dinitroehlorbenzene witl. methylamine (produced from formaldehyde and ammonium carbonate). Dinitromonomethylaniline is formed and is converted to tetryl by a subsequent nitration. The difficult part of this process is the control of the reaction between ammonium carbonate and formaldehyde.

Reference has already been made to the difficulties attending the preparation of dimethylaniline from aniline and methyl alcohol. A considerable amount of work has been carried out at Picatinny Arsenal on the development of the catalytic production of dimethylaniline from the same two ingredients. In brief, the procedure consists in passing the vapors of analine and methyl alcohol through heated tubes containing various catalysts. Pioneer work along these lines was performed by the French chemist Maihle, who employed aluminum oxide as the dehydrating catalyst. This process can be made to yield varying quantities of dimethylaniline and monomethylaniline, so that, should the nitration experiments with the latter substance prove successful, this monomethylaniline ought to be readily available.

Oil Burning Engines For Artillery Tractors

Extensive studies have been made by the Ordnance Department to determine the feasibility of using oil-burning engines in automotive combat vehicles. The principal commercial advantage is cheaper fuel, and while this holds good for any service there are other important military advantages, such as the elimination of the carburetor, magneto, and all electrical wiring, making the waterproofing of the motor a relatively simple matter.

Information covering practically every commercial domestic and foreign oil-burning engine has been obtained, and although there are numerous successful stationary and marine oil-burning engines of the Diesel, Junker, De la Verne and Hvid types, no manufacturer has successfully produced and marketed a motor for automotive purposes that can function satisfactorily on all fuel oils although many are carrying out exclusive tests and have already developed motors that operate on kerosene and the lighter oils.

Samples of crude oil have been obtained from all recognized fields in the United States and Mexico and a large number of samples of so-called "fuel oil" have been procured from widely separated sources to determine the variations to be expected in the crude and fuel oils. These samples have been fractionally distilled, analyzed, and refined. The composition of the crudes was already fairly well known, but a surprising variation was found in the fuel oils which are apparently compounded from "tailings" and the quantity of the various elements appears to vary with the materials available at the time of compounding.

The results of the investigation to date indicate that many of the present troubles are due to residue of black oil, petrolo, tar, and silica, which do not burn in the cylinders of existing engines and result in rapid carbonization with the usual knocking and preignition; also that in the commercial fuel oils there is a large percentage of oil between the kerosenes and the lubricating oils that could be separated at low cost with existing refinery facilities and which would make excellent motor fuel for Diesel or modified Diesel engines weighing not much more per horsepower than the conventional gasoline-burning motor vehicle engines. An engine that would burn this fuel can apparently be developed with-without serious difficulty.

In addition to this at least one firm is making experiments with a special type of engine which by overcharging the air supply and compounding the cylinders is expected to be able to handle even crude oil.

The Synthesis of Ammonia

By

M. GEORGES CLAUDE

[Note.—A lecture delivered before the Societe des Inginieurs Civils de France and published in the April-July, 1922, number of the journal of that Society.[1]]

GENTLEMEN: Since the Haber process has been operated on so large a scale, the Germans, very proud, and rightly so, of an achievement without precedent in chemical industry, have expressed the thought openly that henceforth they need have no fear of being overtaken and that this industry will be their most powerful instrument in the struggle for industrial supremacy in the world.

The capital importance of the problem requires all the more that the challenge be taken up by us since the question is entirely French in origin.

It is to our great chemist Fremy that we owe the first work on the rôle of iron in the fixation of nitrogen. It was to our genial Tillier, creator of the refrigerating industry, that the marvellous possibilities since realized first appeared. If you doubt this, here are the words, truly prophetic, in which he expressed his conviction:

"In conclusion," writes Tillier, "the manufacture of ammonia under the conditions that I indicate[2] involve nothing complicated. It offers infinite possibilities for the production of this substance, since the materials for operation are air and water. Finally, its cost will become such that the production, whether it is a question of industry or of agriculture, will show an unlimited development. The economic production of this substance, in fact, affects the most serious interests. It is a method among all others which can actually be worked; capable of giving the highest returns."

Well, gentlemen, these lines, which might be thought to have been written yesterday, are fifty years old.[3]

Finally, it is to Le Chatelier that we owe the laws of the synthesis of ammonia.

Such were my predecessors in the process in which I have engaged.

I ought no doubt remind you at this time that the principle of the synthesis of ammonia consists in submitting the mixture of nitrogen-hydrogen to the simultaneous action of pressure, temperature and a suitable catalytic material. In the Haber process this pressure is 200 atm., the temperature is in the neighborhood of 600 degrees, the catalyst is essentially iron. It is this process which, perfected by the Badische Company and exploited by them on a colossal scale at the famous Oppau plant, permitted the Germans to do without the Chilean nitrates, and to prolong the war three mortal years.

Evidently it was not from the standpoint of size that I could compete with the powerful Badische Company. All my efforts must be directed toward discovering a more efficacious way for getting what they obtain by size. It was toward high pressure that I turned.

The laws of chemical equilibrium, in fact, state that the ammonia content increases at first proportionately to the pressure. This, however, cannot be true indefinitely, for even at enormously high pressures, the ammonia content cannot exceed 100 per cent.

But where does this inevitable falling off of the rate of increase begin? If it is at the 200 atm. of Haber, it will be of little use to go above this. Now, confirming these fears, the extrapolation of Haber's last results showed that at 1,000 atm. the gain would not be enormous. In place of the proportionality, Figure 1 shows in effect the results of this extrapolation. And it is doubtless this result, together with the ideas already formed and still being formed about the "extremely rapid" increase in difficulties of operation at increased pressure, that has deterred Haber and his capable assistants.

Persuaded, on the contrary, that the increase in pressure would not be difficult, the still very great gains, shown by this extrapolation, have been a sufficiently great impetus to me.

Let us consider a piston P compressing gas in a cylinder starting at atmospheric pressure.[4] Let us proceed by successive stops, each one half of the preceding, say first ½ of the distance, then ¼, ⅛, etc.

At each step, the pressure doubles. It passes from 1 to 2, from 2 to 4, from 4 to 8, etc. One atmosphere is gained then in the first step, 2 in the second, 4 in the third, etc. Now, the mean pressure doubling at each step, but the strokes diminishing by half, the work expended at each step *is the same.* Thus, the *same quantity of energy* gives 1 atm. at the first stage, 2 at the second, 4 at the third and 1,000 at the eleventh, assuming Mariott's law to be exact.

Thus, the more we increase the pressure the less it costs to do it. Such is, in the case of gases, the great encouragement which theory gives to the industrial conquest of high pressure.[5]

But, nevertheless, the progress has been very slow.

Granting that the French railways, under the impulse of Mekarski, very audiciously fixed the pressures of the air tanks placed on the cars at 45 atm. in 1885, then at 60 atm., granting that the compressed gas industry reached, toward 1890, the figures of 150 atm., things have changed little since. Linde, in 1895, operated his liquid air machines at 20 atm., but this is the same pressure that we find at Oppau and Herseburg, used on a very large scale. Thus, thirty years of an epoch, active and fruitful beyond all others, have extended the industrial limit of pressure by only 33 per cent.

It is a question, in any case, of a limit of 400 per cent.

What then are the excuses for this timidity? "A matter of safety, difficulties of attaining it, difficulties of utilization" the engineers answer.

A matter of safety? But we can always use enough

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1 Meeting of April 28, 1922, and May 26, 1922. Memoirs et Compte de Rendus des Travaux de la Societe des Inginieurs Civils de France, April-June, 1922.

2 Successive passage of hydrogen and nitrogen over reduced iron.

3 Ammonia by Ch. Tillier, Paris, 1867.

4 For rigorous reasoning, C is supposed to be placed in a vacuum and the movement of the piston to be slow enough so that the compression will be isothermic.

5 I am not ignorant, be it understood, of the fine work of Tamnan, of Parsons, and of Bridgman, who, from a scientific point of view, and in a static way, have extended the field of our efforts beyond 20,000 atm.

metal—at least up to the neighborhood of 10,000 atm. and we have not reached that—so that safety will be normally assumed. Even at temperatures of 600 degrees, which it is necessary to attain, there are metals which withstand pressures of 1,000 atm. perfectly. Although that has been considered improbable, I have made catalyst tubes which have

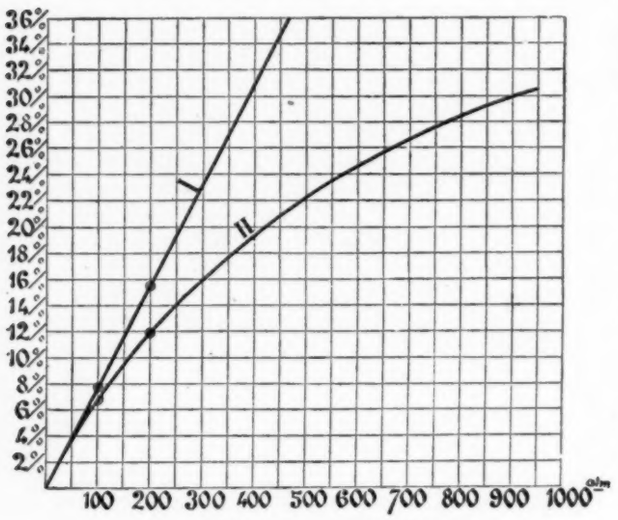

Fig. 1. Extrapolation of Haber's Results

lasted already more than 5,000 hours. Thus, the question is settled.

Difficulties of use? A priori, the great question is the tightness of the joints. But the tightness of a joint depends more on its size than on the pressure that it carries. Now, at hyperpressure, so greatly are the volumes of the gases decreased that a joint for 1,000 atm., all other things being equal, is much smaller than for 100 atm. It is then *easier* to make.

The difficulties of *producing* hyperpressures are no greater. First, by principle, the hydraulic leathers of my hypercompressors work better the higher the pressure is raised. And if it is believed that these hypercompressors are impressive and complicated machines, I will remark that an ordinary compressor of five cylinders of volumes 300, 100, 30, 10, 3 (Fig. 2) compressing from 1 to 300 atm. can be transformed into a hypercompressor compressing to 900 atm. by the simple addition of a very small cylinder of volume 1. Thus, the device that transforms so completely the character and economy of all is very small—almost non-existent.

Fig. 3 shows a hypercompressor in two stages which can supply, at 900 atm. pressure, a plant for 5 metric tons of ammonia or 25 tons of ammonium sulphate a day; you see what a small thing so powerful a machine is.

The operation of these machines has proved so easy that we have ceased to bother with special apparatus for hypercompression; the compressor and hypercompressor are combined in the set-up which is shown by Fig. 4. This machine compresses in 8 stages from 1 to 900 atm. 700 cubic meters of gas per hour, taking 300 H. P. It is designed for the 5-ton-a-day industrial unit which we are going to put in operation at Grande-Paroisse in addition to our 2-ton test plant.

Thus, although it has been thought, and although it is still claimed that there are difficulties in the industrial production and handling of very high pressures, there are none.

What are, in our case, the advantages of these hyperpressures?

I have just said that the extrapolation of Haber's curve was not strongly encouraging. But an extrapolation which takes us from 200 up to 1,000 atm. is not quite legitimate. As soon as I could, in the last days of 1917, I tried direct tests. I had, first, to observe the failure of two of my hopes. First, under these pressures, the reaction is not entirely spontaneous, as might be believed because of the fact that there is a large increase in the velocity of reaction. M. Le Chatilier, to whom I owe many thanks for the constant interest with which he has encouraged and counselled me, hoped also that a catalyzer would be unnecessary. But it has not been. At 1,000 atm., as well as at 200, there was no reaction without a catalyzer. On the other hand, the reaction temperature is not sensibly lowered, which would have greatly facilitated the difficult problem of the reaction tubes; at 1,000 atm., as at 200, the temperatures practicable with ordinary catalysts lie between 500 and 700 degrees.

On the contrary, the equilibrium values are quite notably better than could be expected from the extrapolation of Haber's figures, as we see here (Fig. 5). *Practically*, while the Badische Company gets 6 per cent, I obtain 25 per cent.

Now, this great advantage does not cost very dearly, for the energy for compression increases only with the logarithm of the pressure. If it costs 2.3 to go to 200, it costs only 3 to go to 1000 atm.[6]

Well, if this were all, my process would not be justified. We know that Haber circulates his gas a very great number of times over the catalyst, removing each time the ammonia formed. Since, thanks to this device, 200 atm. suffices to assure practically complete combination, why then burden oneself with the increase necessary to reach 1,000 atm.? The answer is easy; because it is the price paid to obtain a host of advantages.

First, high pressures are not only the key to high concentration of ammonia; they also give us an enormous increase in the activity of the reaction. At these pressures, under the mysterious action of the catalyzer, the classical inertness of hydrogen and nitrogen is completely overcome,

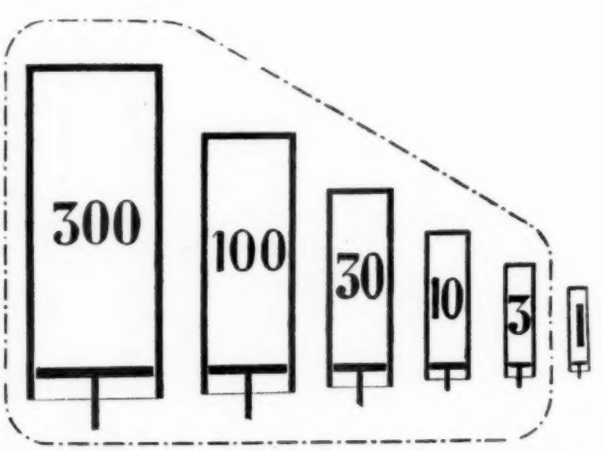

Fig. 2. A Hypercompressor at 900 Atmospheres differs from a Compressor at 300 Atmospheres only by the addition of a small piece of Apparatus

quantities of ammonia are formed in some very small volumes, for a flow of 100 cubic meters per liter of catalyst space per hour, I have exceeded 5 kg. of NH_3 per kilogram of catalyst per hour, in place of 0.5 kg.

Thus, a new and essential characteristic of hyperpressures is that everything is very small, much smaller than would

[6] In fact, we operate at 900 atm. at Montereau. Taking account of the decrease in compressibility and of the larger volume to compress the increase in energy of the compression head amounts to 50 per cent.

result from simple high pressures, and this is evidently an enormous advantage in the cost of installation and of manufacture.

Let us note that at pressures of 1,000 atm., the concentration of 25 per cent so easily attained, corresponds to a partial pressure of ammonia of 250 atm. And as the maximum pressure of NH_3 at ordinary temperatures is only about 7 atm., it is only necessary to pass the catalyzed gas through a coil immersed in water in order to liquefy theoretically more than $\frac{250-7}{250}$ of the ammonia formed.

The Germans, themselves, are very far from this simplicity; a concentration of 6 per cent under 200 atm. gives a partial pressure of ammonia of only 12 atm., as compared with 250, for this partial pressure increases very nearly as the *square* of the pressure. It is necessary for them to dissolve the ammonia formed, in water injected under 200 atm. pressures, which means a large amount of apparatus, *eliminated in my case,* and 7 per cent of the increase in energy recovered. Now, they obtain in this way only an aqueous solution in place of liquid ammonia. It is necessary to remove the ammonia from this solution by means of distilling apparatus, handling, and heating appliances, *which are eliminated in my case.* Then, too, there is the loss of precious cold, which I get, at the rate of 350,000

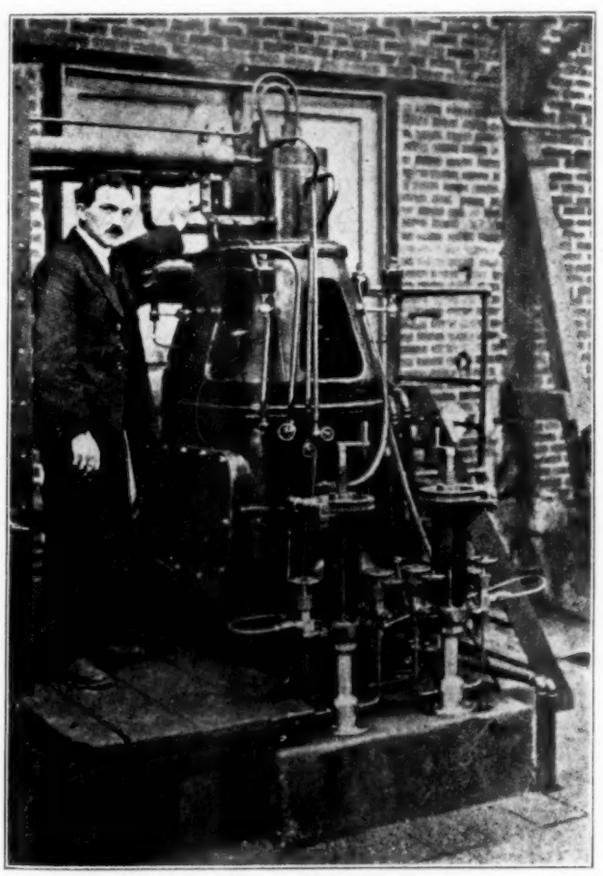

Fig. 3. Two-stage Hypercompressor

calories per ton, from the evaporation of the liquid ammonia, and which, deducted at the rate of 1 H. P. hour per 2,500 calories, saves 28 per cent of the increase in energy.

There is, besides, the elimination, with a saving of another 12 per cent of repeated passage of the gases over the catalyst, as in Haber's case, by means of a circulatory pump which requires a great deal of power; 40 per cent of the gases, instead of 11 per cent, combining at each passage, allow one to pass the gases through 3 or 4 successive cat-

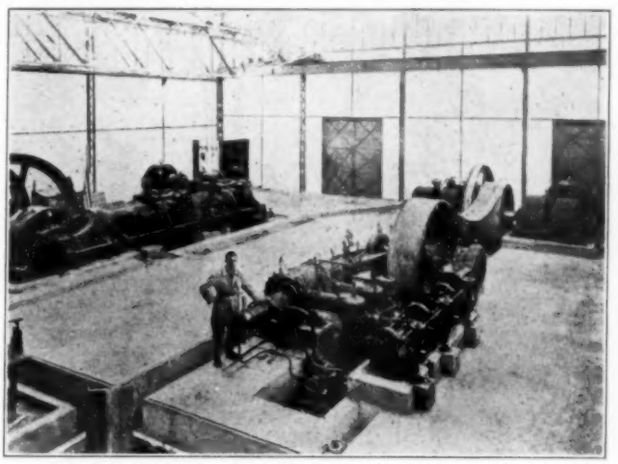

Fig. 4
Combined Compressor and Hypercompressor

alyzers separated by liquefying coils for the ammonia formed.

Haber's heat interchangers are also eliminated, so great is the liberation of heat in my case.

These already are important advantages, but nevertheless there remains to be indicated one which is perhaps still more important. You know all the efforts of the Badische Anilin Company to obtain *rigorous* purification of the gases, indispensible in its process: absorption towers, batteries of pumps, injection of cuprous formate solutions and caustic soda solutions under 200 atm. pressure, regeneration of the products, etc. Now, all this apparatus is needless in my case, which permits a further economy, bringing the recovery of the increased energy to more than half.[7] Surely I had done well in thinking that very high pressures would favor the purification of the gases. However, as my very small catalyst tubes held very little catalytic material, and as this small amount of material must perform on the contrary an immense amount of work, one of our greatest fears was that the infinitessimal traces of impurities would be enough, much more so than in the case of Haber, to completely poison the catalyst. It has, however, been a magnificent success since, for perfect operation on gas containing only 3 or 4 per cent of CO, it suffices to use in the hypercompressed gas line a simple tube heated to 300 or 400 degrees, and containing, for example, reduced iron; the oxygen turns to water, CO to methane and water[8]; the methane does no harm, and the water is removed periodically. With this simple mode of operation, the catalyst lasts more than 200 hours, and that is quite sufficient, for it does not add a centime to the cost of a kilogram of ammonia and it is very easily replaced as we shall see.

I said just now how absolutely simple is the production of high pressures; it has not all been so simple, we suspect, in the technique of ammonia synthesis, and it has often been necessary to struggle against great difficulties, at times unexpected. The hardest has been the increase in the heat of reaction. While one of the difficulties in perfecting the Haber process arose from *the small amount of heat* of a

7 I have, at these points, corrected my calculations to take account of M. Patart's observations.

8 In fact, it is easy to reduce the CO to less than 1 per cent and even to one-half per cent in the method of preparing hydrogen by liquefaction, which will be mentioned later, and the loss of hydrogen itself is small.

reaction limited to 11 per cent of the reacting gases, there are great quantities of heat liberated from the combination of 40 per cent under 1,000 atm. pressure in the very small volume of the catalyst tubes; 60,000 calories per hour for a tube of 10 cm. bore and 2 meters long.

Now, it is necessary to get rid of this heat, and to do so

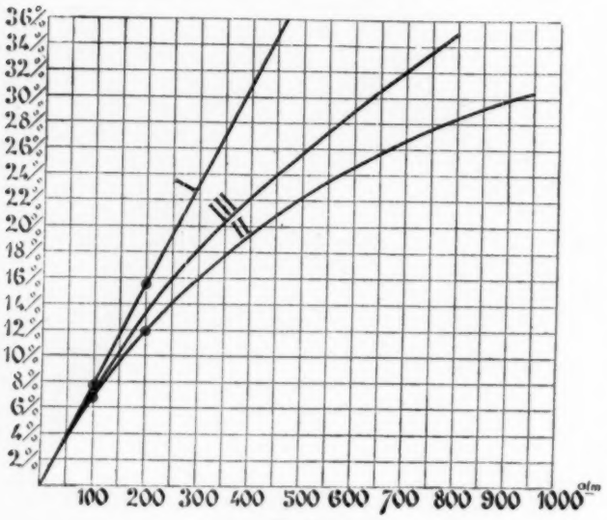

Fig. 5
Equilibrium Value of Ammonia Content

at the exact temperature which is most favorable, under penalty either of unpriming the tubes if they are cooled too much, or, on the other hand, of endangering the tubes by too high a temperature, which, besides, destroys the chemical equilibrium.

The problem is then to get rid of the heat of the reaction as soon as it is produced so that catalysis takes place all through the catalyst material exactly at the most favorable temperatures, about 550 degrees as a compromise between a good equilibrium value and a rapid rate of reaction.

Evidently, the gases should reach the catalyst material already heated to the temperature of reaction. I first heated them, therefore, as in the Badische process, by means of the exit gas. I got rid of the heat of reaction, then, under the exact conditions that I have specified, cooling the tube by a bath of *melted lead*, a strange refrigerant, which circulates along the tube on the thermo-syphon principle.

That went very well until an unexpected difficulty came up. When I wished to increase the output of my tubes, they commenced to split. Not very dangerously, however, for it is another peculiarity of these hyperpressures (I would lay stress upon this if I had time), that splitting, or bursting, is in general entirely harmless. But, by another freak, these splittings always started *on the exterior*, as Fig. 6 witnesses. Here is, however, the explanation: the transmission of a strong flow of heat from the core of the tube towards the exterior, produces a high temperature gradient through the very thick and *poorly conducting* walls of this tube, just as a flow of electricity produces a potential gradient; the interior layers, very much hotter, exert therefore, a pressure on the exterior layers, which, adding disastrously to the working pressure, causes their rupture, and then that of the whole tube.

The cause of the trouble having been found, a remedy presented itself. To avoid the danger, it is necessary to prevent all transfer of heat from the interior to the exterior of the tube. This is not difficult. It suffices to place it, with its electrical priming circuits, in a suitable heat insulator, asbestos or kieselguhr. The most annoying feature is that the heat of reaction can no longer be dissipated through the walls.

I was able to learn, from this false step in operating, a peculiarity, wholly fortuitous, of the use of hyperpressures.

It is found, in fact, that with the rate of combination obtained around 1,000 atm. with ordinary catalysts, the heat of reaction could, dissociation apart be it understood, heat the reacting gases approximately some 500 degrees. It should then be possible to introduce the gases to be treated at approximately the temperature of the reaction, supposing them to be taken at the temperatures of the surroundings.

Instead, therefore, of heating the inlet gases in a heat interchanger, I introduce them *cold* into the apparatus (Fig. 7). The catalyst material fills an inside tube with thin walls, which the entering gases strike before reaching at B the catalyst material. Proceeding, they are heated at the expense of the heat of reaction, in the *same proportion* in which this is produced. For this effect, the inside tube is covered with heat insulation, *progressively decreasing* from the inlet of such a thickness at each point that the entering gas absorbs at this point exactly the amount of heat which is liberated there by the reaction. Thus, the reaction can take place, if the proportionality is exact, at the most favorable temperature from one end of the tube to the other, while the gases reach the catalyst material exactly at this temperature.

Thus, conceived to overcome a serious difficulty, this arrangement has proved besides to have valuable qualities.

First the heat interchangers are eliminated.

Then, the gases entering cold, and being heated only slowly, the outside tube, protected by them from the central heat, has no longer to withstand the high temperature except at the other end, where it can be increased in thickness, and this gives a longer life to the tube.

Finally, and above all, the inlet side being at the surrounding temperature, all difficulties of joints at the movable head which closes the tube disappear. It has been

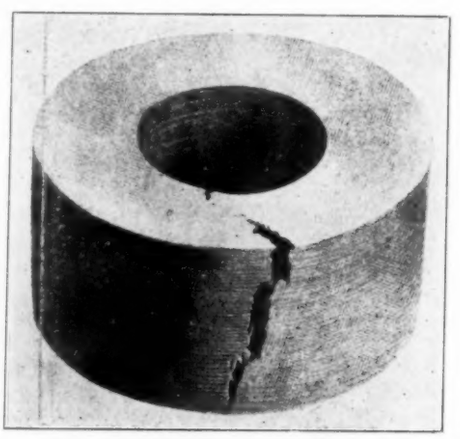

Fig. 6
Section of a split Catalytic Tube

possible, therefore, to make this head and the internal tube containing the catalyst material, quite readily removable, and it can be taken out when the catalyst has ceased to function, in order to substitute another containing new catalyst. A simple rotation of a quarter-turn suffices to make or unmake the joint, thanks to an arrangement similar to the breech of a gun, and as the heavy external tube remains in place in its heat insulator, and at the usual tem-

perature, the replacement of the catalyst material becomes as easy as changing cartridges in a large caliber gun.

Such is, in its essentials, the synthesis of ammonia by hyperpressures.

The increase in energy required for the higher pressure is in large measure balanced by the gain in energy realized at each step. The cost of power amounts, after deducting the energy produced by the evaporation of the ammonia at the rate of 1 H. P. hour per 2,500 calories, to 1.5 H. P. hours per kg. of NH_3 for a single catalysis, against 1.25 in the Haber process. But as little as this difference is, it is only a very small side of the question, for it is an incomparable gain with these hyperpressures to *eliminate a large number of operations*, a quantity of apparatus henceforth useless, and to *decrease enormously in size what remains*. It is quite evident that the certainty of operation should be increased by this and that the cost of the plant will be diminished in a corresponding measure. This reduction depends, it is true, on the size of the apparatus. For 10-ton units compared with the apparatus at Oppau, it would be not less than 25 per cent.

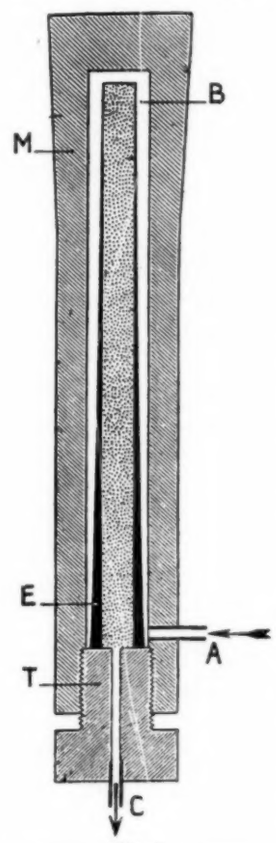

Fig. 7
Cross Section of Catalytic Tube

It is true, because Haber has mentioned in his patents 200 atms. *and above*, that the Badische people would claim readily the use of hyperpressures. But all the texts of the Badische people and of Haber establish clearly that they had in mind the highest pressures *then* realized industrially, not an order of pressures entirely different. To claim now the benefit of these hyperpressures, which did not exist, which were not foreseen, which had to be realized by another, and that without having said a word and for good reasons, of the difficulties that arose, nor of the remedies which they necessitated, this would be already convincing if Haber's invention, like Minerva of antiquity, had sprung fully armed from his own brain. Now, we know well that such has not been the case, the ideas of Tillier and of Le Chatlier, the experiments of Nernst, among others, have made public property the fundamental principles of the synthesis; now, only the details can be patented. Haber's process is one of them, mine is another.

I come now to the point which dominates the whole question. One part of inexpensive nitrogen combining with three parts of expensive hydrogen, the nitrogen problem is at bottom a problem of hydrogen. Here again, the special facilities offered by hyperpressures have suggested a method very different from that of Haber.

The skillful perfecters of the Haber process, admiration for whom will never be lacking from me, have had to contrive a way of making hydrogen, otherwise quite remarkable, adapted to the exigencies of their synthetic process. This in fact seems to require very large plants, of 100-ton capacity, at the least, and such plants necessitate making on the spot the hydrogen used for the necessities of operation, at great expense and requiring a large supply of coal.

With hyperpressures, on the contrary, the apparatus can be *as small as is wished*. It then becomes possible to install it wherever byproduct hydrogen is lost from existing industries. The inefficiency of the small apparatus is largely compensated both by the cheapness of the hydrogen and by the elimination of the large amount of equipment required for its production.

With this idea in mind, a truly exceptional source strikes the attention; this is the coke furnaces so common in France, England and Germany, the gases from which, composed of more than 50 per cent hydrogen, are still very often so poorly utilized. It is to this source that I wished to direct my attention.

Here, it is true, the hydrogen is delivered in an extraordinarily complex mixture—mixed with nitrogen, carbon monoxide, methane, ethane, butane, ethylene, carbon dioxide, hydrogen sulfide, etc.

My idea has been to extract the hydrogen by a suitable *physical method* and to return the other gases to the plant, *much richer*, moreover, from the calorific standpoint.

In principle, the process of liquefaction furnishes the necessary method, for hydrogen is, by far, the least condensible of all these gases.

Here is, in the simplest case, that of a mixture of equal volumes of CO and H_2, called *water gas*, the process which I conceived and have tested, starting in 1903.

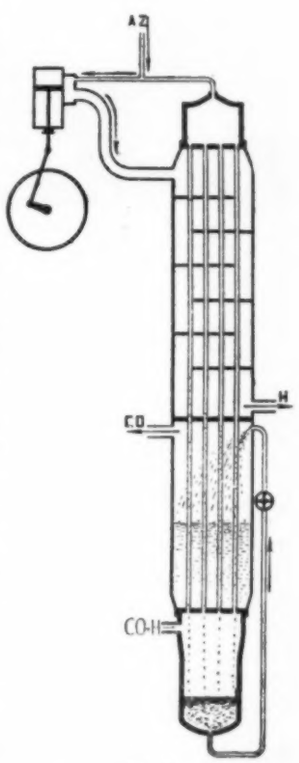

Fig. 8
Schematic Diagram of Apparatus for Physical Extraction of Hydrogen from Water-gas

The gases, compressed and purified, are cooled in a heat interchanger in the inverse direction from that of the hydrogen and carbon monoxide previously separated. They then enter (Fig. 8) a vertical set of tubes whose lower ends are immersed in a bath of CO boiling at 190 degrees under atmospheric pressure. Under the influence of this bath, a very large part of the CO in the ascending gas is liquefied, flows down into the collector C to be raised by V to the external bath, where it partially replaces that which evaporates. The remaining gases continue to rise in the set of tubes; they meet there (we shall see how) *a temperature even lower*, under the influence of which the remaining CO is liquefied. Compressed hydrogen alone, therefore, leaves the top of the tubes, and this hydrogen, expanded in the motor M, and still further cooled by this expansion, and sent back around the set of tubes, produces there the very low temperature which we have just mentioned. That is all.

Except that this is theoretical. In fact, the results are much poorer, for at —210 degrees, which is necessary to condense all the carbon monoxide, no lubricant known can stand up and assure operation of the motor. I had then given up, when an idea, which I believe instructive, for it proves once more that it is indeed rarely that some property of matter

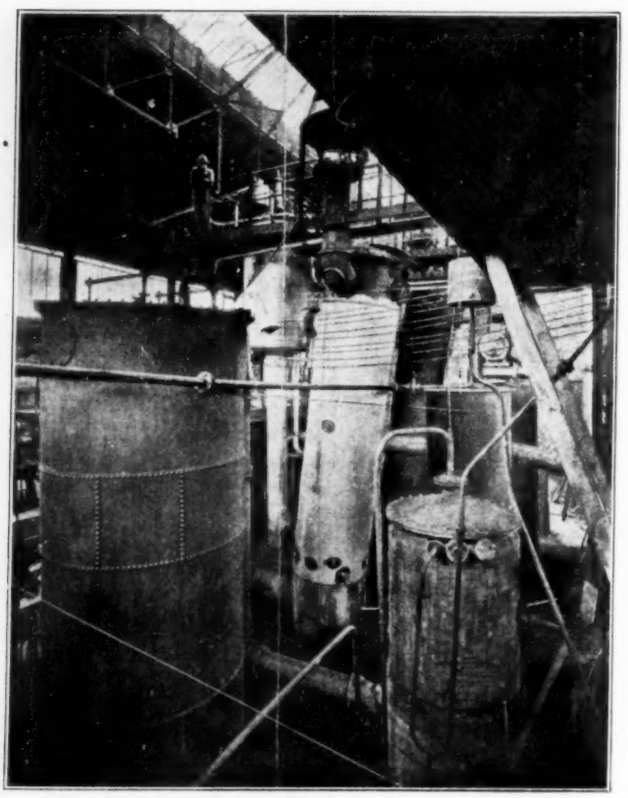

Fig. 9
Battery of Hydrogen Generators—Haber Process

is not capable of solving the worst problem simply—when a very simple idea, then, settled the question: as the hydrogen produced was to be used in making ammonia, a little nitrogen would do no harm. Nothing prevents, then, returning to our apparatus, mixing through a little nitrogen with the hydrogen to be expended. This nitrogen changes to vapor at the end of each expansion, and as it freezes only at —210 degrees, it assures the lubrication of the motor, and the apparatus operates.

Thus was assured the success of a method whose *extreme importance* you will appreciate when I tell you that the production of the cumbersome battery of gas generators, which are here (Fig. 9) shown, will be transferred by two set-ups like this (Fig. 10) into 24.000 cubic meters of hydrogen a day; enough to make four carloads of ammonium sulphate.

But I emphasize this point, this work on water gas was only preliminary by way of preparation with the view of the solution, more complex from the standpoint of liquefaction, but much more rational, of the problem of gas from coke furnaces. Having solved the simple case, that of water gas, I passed to the complex one, that of coke-furnace gas.

I have the great pleasure of saying here that thanks to the kindness and loftiness of view of our good ex-President, M. Louis Mercier, Director General of the Mines at Bethume, and of his son, M. John Mercier, with the devoted help of their personnel, and the large amount of experience acquired on water gas, our progress in this direction has been very rapid; an apparatus treating 800 cubic meters of gas an hour, which was installed at the Bethume mines some months ago, is today in regular operation. Before long an installation for making ammonia of 3 tons capacity a day, which is already in process of erection, will use the hydrogen from this apparatus—and thus the realization of my promise will be begun through this still very modest installation, without any lasting technical disillusion having occurred in the course of my trials.

Finally, the total net power cost of the coke-oven Claude process figures at 2.9 H. P. hours per kilogram of ammonia, as compared with 2.2 for Haber. You see of what slight importance 25 francs per ton of ammonia, on the pre-war basis of M. Patard, is to a scheme, which, taking inspiration from the views of great modern industries, calls for a larger use of mechanical energy, and a better use of the properties of matter, and at the same time, the use of abundant by-products, *the extreme simplification* of the plant, and of the operations. *The whole question centers in that*, and it is in that alone, for the reduction of the cost of ammonia is its obvious consequence.

Moreover, it is not only in permitting the very advantageous utilization of hydrogen that the new method will force itself upon the attention of the coke-oven industry, but also through all sorts of interesting side lines.

We know, for example, the precarious conditions which ordinary solvents impose on the removal of benzol from coke-oven gas, and the poor solvent properties of heavy

Fig. 10
Apparatus for Physical Extraction of Hydrogen

oils. It is quite evident that if this removal could be effected under pressure, the conditions would be radically changed. As soon then as pressure becomes the basis for hydrogen removal, it is clearly indicated that we profit from this. Then the 3 or 4 grams of benzol actually lost in a

cubic meter of gas will be recovered; then the amount of solvent, the amounts lost, the size of the absorption and distilling apparatus will be reduced a tenth.

That is not all. Coke-oven gas contains valuable substances, ethylene for example. Some interesting attempts have already been made, especially by M. de Loray, to extract this gas and to make alcohol from it but, with the amounts present, 1 or 2 per cent, this extraction of ethylene is difficult by present methods. Now, our tests at Bethume have shown that it is very simple, in the process of liquefaction, to extract a good part of this ethylene in a nearly pure state.

Lastly, since by a happy circumstance, hydrogen has the least calorific power of all combustible gases, the gases remaining after the extraction of hydrogen are much richer. They are capable of giving much higher temperatures.

Leading to the use of marvellously simple machines, in which the congestion due to the scrap iron of the gas generators will remain unknown, in which the enormous specific power of the gas liquefying units will form a harmonious counterpart of the catalytic set-up, strongly supported by all the side lines which I have mentioned, there is no doubt at all that the synthesis of ammonia by hyperpressures will be welcomed with favor by the coke-oven industry. No doubt even that, if the agricultural outlet opens sufficiently, we will be led to remove the hydrogen from all gaseous products, including the gases from heating furnaces. My modest conception of small units added to all sources of waste hydrogen will then be greatly exceeded by reality, for this will necessitate powerful apparatus, of low unit cost, with reduced labor costs. Then the single inferiority of this scheme will disappear.

Moreover, without waiting longer, we are experimenting with a plant of 50 tons a day capacity, the first section which will comprise a 2,000 cubic meter hydrogen unit supplying two groups of catalyzers each of 10 tons capacity. A 20-ton set is likewise being considered. Now, these plants cost less than 500,000 francs per ton capacity, including the transformation of the ammonia, less than 500,000 francs against more than a million for Haber.

There are definitely established the foundations of an industry capable of furnishing practically unlimited quantities of ammonia. But in order for it to be developed, it is necessary that agriculture be in condition to absorb all the ammonia produced.

First, can it do this theoretically? Yes, certainly. There are in France, including Alsace and Lorraine, more than 15 million hectares (1 hectare=2.47 acres) under cultivation. On each 250 kg. of ammonium sulphate, 50 kg. of nitrogen could be used to advantage. That leads to the fantastic figure of 800,000 tons of possible ammoniacal nitrogen; certainly this limit of limits is purely theoretical, but actually we use 20,000—we use twenty times less nitrogen per hectare than does Belgium.

When the day comes in which the cost of nitrogen will no longer be an obstacle to its widespread use, the demand will be enormous; several authorities on the matter give assurance of this.

It is superfluous to say what benefits will result to our agriculture from this, since 50 kg. of nitrogen often double the yield. It will be the greatest blow to the cost of living, and it affords therefore a fine field in which to work.

Now, in reality, the only form of ammoniacal fertilizer, at least in France, is practically speaking, ammonium sulphate. But in this material, the cost of nitrogen, as it results from the synthesis, is increased 80 per cent by the use of sulphuric acid.

Then, in spite of the synthesis, there is nothing to do, or very little, to lower the cost of ammonium sulphate much below the usual price of sulphate from gas-works, in which it can almost be said, ammonia costs nothing.

But it is quite different if, in place of expensive sulphuric acid to fix the ammonia, we use the chlorine from common salt, which is lost in immense quantities in the Solvay soda industry; that is to say, instead of making the sulphate, we make the chloride. An important point comes up here, every time that a ton of ammonium chloride is made, there is also made a ton of sodium carbonate.

The operation is so much more advantageous, that, in the process which I have perfected with the help of my collaborator, Mittan, and in which the great amount of cold produced by the liquid ammonia of my process plays an important part, this ammonium chloride and sodium carbonate are obtained with ideal ease, without distillation, without expensive evaporations, by *alternate precipitations* in the same liquid.

Thus understand, with the return from the sodium carbonate, the transformation of ammonia into fertilizer should no longer cost an appreciable amount.

Nitrogen, as chloride, could then be sold at a much better figure than could the sulphate, so that this necessary lowering the prices of nitrogen depends on the conversion of the agriculturist to the use of ammonium chloride as it will be produced. An obstacle which, moreover, is very often found to be only in habit, for numerous tests have already shown the exact equivalence in most cases of nitrogen as chloride and as sulphate.

But here, too, things are interrelated; in order to sell the chloride, it is necessary to have a market for the sodium carbonate produced; the actual outlet for this permits the production of synthetic nitrogen to the amount of 100,000 tons a year. In order to increase this figure, it will be necessary to sell more soda, and for this, to engage in the fight against filth, the struggle for hygienic conditions.

And we see how all this is related to the welfare of the country, for we are constrained by the force of circumstances to rise above the egotistic satisfaction of particular interests. In order to lower the cost of coke and thus to develop our coke furnaces, it is necessary to sell a large amount of ammonia; for this, it is necessary to obtain it at a price low enough so that the agricultural industry will be forced in spite of itself into progressive methods; but that is possible only through ammonium chloride, which requires that, in its turn, the market for soda follow the line of progress, to the greater benefit of public hygiene.

Here, then, if what is perhaps a rather daring forecast from actual realities be pardoned, are the foundations of an industrial policy truly national, of a policy which can be followed without shame.

[NOTE.—ARMY ORDNANCE is indebted to Mr. F. E. Smith, Junior Chemist, Fixed Nitrogen Research Laboratory, Washington, D. C., for the translation of the above article from the French.—Ed.]

Roger Bacon's Gunpowder

By

TENNEY L. DAVIS

WHILE a natural interest attaches to the antiquity of a material which has revolutionized warfare and has brought on the age of iron and steel, a particular interest attaches to Roger Bacon's description of black powder for the reason that it is perhaps the oldest known authentic account of that material. The various works which deal with explosives and with the history of science report what is supposed to have been Bacon's formula for the preparation of black powder, but an examination of the original source of information shows that current reports of the precise formula are certainly in error. To an examination of Bacon's meaning the present paper is devoted.

Roger Bacon

The description of black powder occurs in a letter[1] (written in 1252) "Concerning the Marvellous Power of Art and of Nature and Concerning the Nullity of Magic," and is concealed in enigmatic language and obscured by verbiage similar to that which was preferred or affected by the alchemists of the Middle Ages. The language has been clarified by the ingenuity of the Englishman, Lieut. Col. H. W. L. Hime,[2] who supposes that it is written in the style of the Argyle cipher of "Henry Esmond." While the whole appears more or less connected and carries an apparent and superficial meaning, the secret sense is conveyed by a few words only. The significant words are not written in any regular sequence or with definite intervals between them, and the key to the cipher is evidently a piece of parchment with holes in it. When this is superimposed upon the page of writing, the words which appear through the holes constitute a clear and connected description of the preparation of black powder.

Bacon's letter on the Nullity of Magic appears to have been addressed to some high official of the Church and was evidently written as a defense against the charge that he was devoted to magic and the practice of the black art. He points out that many phenomena commonly reputed to be magic are really due to the natural operations of Nature—and fortifies his position by reference to many natural things which are marvelous. It commences, "I am responding to your request. Even if Nature is powerful and marvelous, yet Art, using Nature for an instrument, is more powerful by virtue of Nature, as we see in many instances. Indeed, whatever is beyond the operation of Nature and of Art is not human or is a fiction and the doing of fraudulent persons." Bacon speaks of the simple deceits which are practiced by ventriloquists and jugglers, and makes the profound observation that "truly, popular opinion does anything that men wish it to do, so long as men are agreed about it." He speaks of the invocation of spirits, and of charms, incantations, and magic practices. His remarks on the therapeutic value of auto-suggestion are not surpassed in scientific accuracy by the latest observations on the subject. He continues with a discussion of the force of personality, of good and of evil temperaments, and then proceeds to describe certain mechanical devices, the pulley by which great weights may be moved, and boats and carriages which shall move under their own power. He speaks of the possibility of the flying machine. He tells of optical devices, of magic mirrors, of instruments by which "we may see objects however small they may be," and of burning glasses. It appears that he was familiar with lenses, for he says that burning glasses "function in both directions."

"In addition to these marvels, there are certain others which do not involve particular constructions. We can prepare from saltpeter and other materials an artificial fire which will burn at whatever distance we please. The same may be made from red petroleum and other things, and from amber, and naphtha, and white petroleum, and from similar things. Pliny reports in his second book that he defended a certain city against the Roman Army, and, by throwing down incendiaries, burned the soldiers in spite of their armor. Greek Fire and many other combustibles are closely akin to these mixtures.

"Beyond these are still other stupendous things in Nature.

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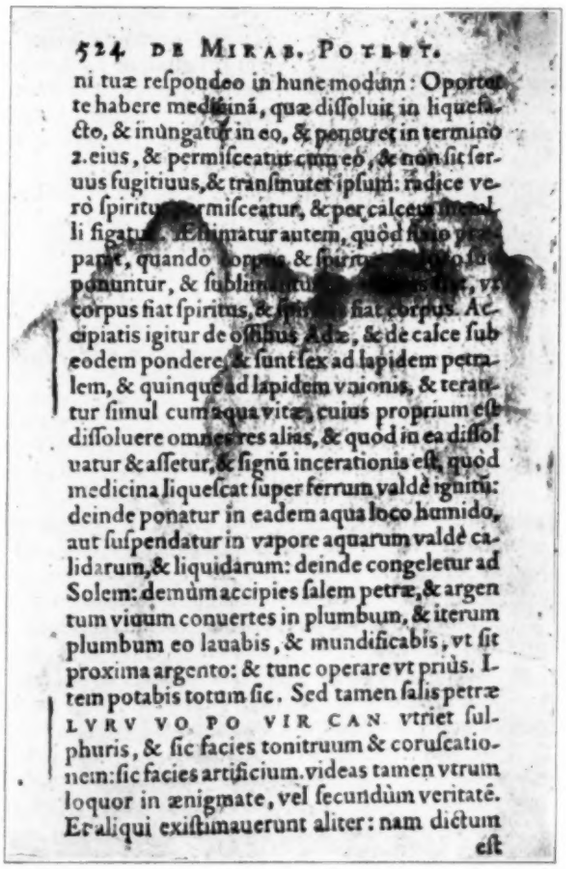
1 *Fratris Rogerii Bachonis Anglici, De Mirabili Potestate Artis et Naturae, Libellus*, printed in the second volume, pp. 494-525, of a collection of alchemical writings entitled *Artis Auriferae quam Chemiam vocant* (Basileae, 1593, 2nd ed.). The date of the letter is fixed by the fact that it contains the passage, "In the six hundred and thirtieth Arabian year I respond to your request in this fashion." Since the Arabians date their calendar from the Hejira or flight of Mohammed from Mecca to Medina, July 15th, or better, new style, June 20th, 622, Bacon's letter must have been written in the year 1252. A translation of the entire tract, with discursive notes, is soon to be published by the Chemical Publishing Company.

2 Article, "Roger Bacon and Gunpowder," p. 321, in the volume "Roger Bacon—Essays—Contributed by various writers on the occasion of the commemoration of the seventh centenary of his birth." Collected and edited by A. G. Little, Oxford, 1914. See also Hime, *Jour. Roy. Artillery*, July, 1911.

For the sound of thunder may be artificially produced in the air with greater resulting horror than if it had been produced by natural causes. A moderate amount of the proper material, of the size of the thumb, will make a horrible sound and violent coruscation.—These are miracles, if accepted according to their account in size and in substance."

Bacon then deserts the subject of black powder for a time. He speaks of a self-actuated working model of the heavens, of the alloying of gold, and devotes considerable length to a discussion of the prolongation of human life, a subject which seems to have interested him deeply. He speaks wisely of the care of the health and of the things which may be accomplished by a regimen of diet and exercise. He then speaks of the wisdom of concealing secrets from the vulgar crowd who are ignorant and stupid and will misinterpret what they cannot understand. He enumerates seven ways in which this may be done and proceeds to make use of some of them in the last part of his letter which is devoted to the enigmatic description of black powder.



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ni tuæ reſpondeo in hunc modum: Oportet te habere medicinã, quæ diſſoluit in liqueſacto, & inũgatur in eo, & penetret in termino 2. eius, & permiſceatur cum eo, & non ſit ſeruus fugitiuus, & tranſmuter ipſum: radice verò ſpiritus permiſceatur, & per calceum [illegible] li figatur. Æſtimatur autem, quòd [illegible] parat, quando [illegible] & ſpiritus [illegible] ponuntur, & ſublimantur [illegible] corpus fiat ſpiritus, & ſpiritus fiat corpus. Accipiatis igitur de oſſibus Adæ, & de calce ſub eodem pondere: & ſunt ſex ad lapidem petralem, & quinque ad lapidem vnionis, & terantur ſimul cum aqua vitæ, cuius proprium eſt diſſoluere omnes res alias, & quod in ea diſſoluatur & aſſetur, & ſignũ incerationis eſt, quòd medicina liqueſcat ſuper ferrum valdè ignitũ: deinde ponatur in eadem aqua loco humido, aut ſuſpendatur in vapore aquarum valdè calidarum, & liquidarum: deinde congeletur ad Solem: demùm accipies ſalem petræ, & argentum viuum conuertes in plumbum, & iterum plumbum eo lauabis, & mundificabis, vt ſit proxima argento: & tunc operare vt priùs. Item potabis totum ſic. Sed tamen ſalis petræ LVRV VO PO VIR CAN vtriet ſulphuris, & ſic facies tonitruum & coruſcationem: ſic facies artificium. videas tamen vtrum loquor in ænigmate, vel ſecundùm veritatẽ. Et aliqui exiſtimauerunt aliter: nam dictum eſt

Page from Bacon's Tract, Showing the Formula of Black Powder in enigmatic Language and in an Anagram

"I say to you, therefore, that I wish to set forth in an orderly manner the things which I have narrated above. I wish to describe the Philosophers' Egg and to investigate the parts of Philosophic man, for thereby is an initiation to other things."

Bacon's choice of the Philosophers' Egg as an emblem under which to hide his description of black powder is well advised for the reason that the Egg was a favorite symbol in alchemistic writing. Associated with the idea of fecundity, with the egg of siris, and with the Egg of the Universe which Khoum put forth from his mouth when he desired to create, the Philosophers' Egg of the alchemists stood especially for the goal of their work; it was the Philosophers' Stone which was the object of their labors. Bacon's description of it is written in language which resembles very closely the usual writing of the alchemists. He describes the Philosophers' Egg three times, and to a careful reader it seems that with repetition he adds a little to what he has said before or says more clearly the thing that he darkly hinted in an earlier passage.

The first part describes the purification of saltpeter, not precisely the Philosophers' Egg, but as Bacon says, "rather the goal and purpose of the Egg." The salt is dissolved in water and the solution is boiled until the scum has risen to the top. The scum is removed and the solution allowed to crystallize. The mother liquors are evaporated for another crop of crystals, and the crystals are piled up in a warm place to dry.

Bacon speaks of his substance as a "salt" but he adds to the confusion of the reader by calling it by a variety of other names, the *"fusile sulphur* of the Philosophers," "camphor," an "oil which is like a salve or a viscous cheese not to be broken asunder by the first thrust," etc. The expression "aerial humor" indicates the substance he is talking about, and his statement that it is "sometimes called the conjunctive substance which fire does not separate" may perhaps have reference to the fact that saltpeter converts many infusible substances into glass or slag.

The style of the writing may be illustrated by the following quotation in which the English words corresponding to the Latin words of Colonel Hime's choice are printed in italics and inclosed in brackets.

"Grind [*the salt diligently*] with waters and [*purify*] it by other grindings with waters, rub it up vigorously in various contritions with the salt, and burn it with many blasts [*so that a pure earth shall be made free from other elements*] which I hold worthy for your purpose by the stature of my height. Understand this if you can; for without a doubt there will be a composition from the elements and so there will be a part of the stone which is not a stone, which is in every man and which you will find in its proper place in every season of the year. . . . Let its whole fiery virtue be divided, and let it be separated by dissolution. [*Let it then be dissolved in*] acute [*water*] of moderate acuteness [*with gentle heating and let it be boiled until its scum has separated*] as the scum or fatness of flesh is separated by distillation, so that the black virtue in which urine is distilled shall not issue forth to the liquid from its unctuosity. . . . It is better, however, that it should be boiled in waters of temperate acuteness [*until it is purged and whitened*], and the salutary concoction may be in a moist or in a dry fire. [*The distillation is repeated*] in order that it may sufficiently take on the right degree of goodness [*until is is rectified—and the newest signs of the rectification are candor and crystalline serenity.*] When other things are blackened by the fire, this is whitened, and is purified, and shines with serenity and marvellous splendor. [*From*] its [*water*] and earth quicksilver is generated, because it is like the quicksilver in minerals. When [*the substance*] has been whitened in this way, it [*is frozen—the true aerial stone, which is not a stone, and it is placed in a pyramid in a warm place*], or, if you wish, it is put away in the belly of a horse or ox in acute fever. . . . You know indeed that when you shall have consummated this operation it will behoove you to begin another."

From the connectedness and intelligibility of the italicized words it is apparent that Colonel Hime's suspicion concerning the nature of the cipher is something more than a happy guess. At the same time it is perfectly apparent that Hime's choice is not the only possible choice; words which

he has omitted might very well have been intended to be read—for instance, Bacon might have intended, "until it is purged and whitened, and the salutary concoction may be in a moist or in a dry fire," that is to say, in the water bath or over a free flame. "The distillation (i. e. solution) is repeated in order that it may sufficiently take on the right degree of goodness until it is rectified," etc. Perhaps Bacon intended the statement that the salt is whitened and purified by fire to be a significant and suggestive part of the description of his substance. Moreover, "the belly of a horse or ox in acute fever" is good alchemical jargon and means an oven moderately heated. Indeed, I am tempted to believe that the enigmatic writing of Bacon requires no key for its cipher, but that the secret meaning is to be found by reading between the lines.

Having described the purification of saltpeter, Bacon writes that there is another secret, a substance of such sort that "it is not possible that the humidity should be separated by vapor—nor does this constitute any object." This appears to be a darkly-veiled reference to charcoal, a substance, by the way, which Bacon does not anywhere name specifically, for he seems to have regarded it as the deepest part of the secret.

There is also a "third chapter in order that you may understand the key of the work that you seek." "A calcined substance also is to be added at some time, and this of such a sort that the humor in it is corrupted by salt and sal-ammoniac and vinegar, and that it is consumed by quicksilver and is sublimed from it until a powder remains." This third substance is plainly sulphur, for mercury and sulphur, both of them volatile, combine to form mercury sulphide non-volatile except on strong heating.

The first, then, of the three enigmatic descriptions of the Philosophers' Egg indicates that three substances are required for its preparation. The purification and properties of one of them is described, the nature of the second is indicated vaguely, and sulphur is plainly suggested as the third.

In the second description of the Philosophers' Egg, Bacon adds new details about the purification of saltpeter, in particular about the recovery of material from the mother liquors. He speaks of a substance, "the secret of secrets of Nature, able to do miracles," which is evidently to be added to the liquid for the purpose of clarifying it. He makes it clear that the Philosophers' Egg is to be prepared from "certain parts of burned shrubs or of willow"—and this is his clearest reference to charcoal—from the "stone of Tagus," which certainly means saltpeter, and from the "vapor of Pearl," an enigmatic expression which evidently indicates sulphur by reference to the pearly appearance of the sulphur sublimate.

The third description of the Philosophers' Egg, if the sentences which contribute nothing to its significance or which only increase its obscurity are omitted, is as follows:

"Take then of the bones of Adam and of the Calx, the same weight of each; and there are six of the Petral Stone and five of the Stone of Union. Let them be ground up together with *aqua vitae* (whose property it is to dissolve all things) until they are dissolved and assated, and the sign of the inceration is that the material melts when it is placed upon strongly heated iron. Then it is placed in the same water in a moist place or suspended in the vapor of hot water or some other liquid, and finally it is congealed in the sun. . . .

"However,[3] of saltpeter LVRV VO PO VIR CAN VTRI and of sulphur, and so you will make thunder and lightning, and so you will turn the trick. You will see moreover whether I am speaking in an enigma or according to the truth."

Colonel Hime has rearranged the letters of the anagram as follows:

R. VII. PART. V. NOV. CORVL. V. ET

which makes the passage read, "However, of saltpeter take[4] seven parts, five of young willow (charcoal), and five of sulphur, and so you will make thunder and lightning," etc. But evidence in Bacon's letter itself indicates that this solution is false. For greater certainty Bacon has three times described the preparation of the Philosophers' Egg, and, unwilling that the whole weight of his secret should hang on an anagram, he has also set forth his formula in language but slightly enigmatic.

"Of the bones of Adam[5] and of the Calx the same weight of each" evidently means equal parts by weight of charcoal and of sulphur. When the additional information is given that six parts of the Petral Stone, saltpeter, are to be taken for every five of the Stone of Union, it is easy to deduce the formula of the mixture—six parts by weight of saltpeter, five of sulphur, and five of charcoal. The materials, as Bacon says, are ground up together under alcohol and dried in the water-bath and finally in the sun. The rectified anagram, accordingly, would be—

R. VI. PART. V. NOV. CORVLI. V. ET

and Bacon's formula for gunpowder was—

Saltpeter	6 parts	37.50 per cent
Young willow (charcoal)	5 "	31.25 per cent
Sulphur	5 "	31.25 per cent

This is not a very good formula for black powder, but Bacon probably had no knowledge of guns; and there can be no doubt that his mixture would make passable fire-crackers and that "a moderate amount of the size of the thumb" would make "a horrible sound and violent coruscation."

The Greek Fire of the Byzantines was invented about 673 A. D. by the engineer Callinicus and consisted of two impregnated with saltpeter and combustible materials like petroleum or pitch. Saltpeter was the secret ingredient; the Byzantine writers failed to mention it when they wrote down descriptions of their fire which were complete in other respects. They kept the secret well, but the Saracens at length learned about it and used it with good effect against the Christians at the time of the Fifth Crusade. Arabian writers described Greek Fire. They knew and named all of the ingredients and probably prepared pulverent mixtures of the nature of gunpowder. Bacon probably learned his secret from them, but he deserves the credit that he brought it to the attention of modern Europe. Guns were in use less than seventy years after he described black powder.

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[3] *Sed tamen salis petrae LVRV VO PO VIR CAN utriet sulphuris, et sic facies tonitruum et coruscationem: sic facies artificium. Videas tamen utrum loquor in aenigmate, vel secundum veritatem.* Certain writers seem to have had versions in which the anagram was printed LURU MOPE CAN UBRE or LURA NOPE CUM UBRE. When these are rearranged, the letters read *varbonum pulvere*. Kopp, *Geschichte der Chemie*, III, 227. Braunschweig, 1845. Escales, *Schwartzpulver und Sprengsalpeter*, p. 5. Leipzig, 1914. Bacon mentions specifically saltpeter and sulphur, the inference is easy that the anagram signifies *charcoal*, and these versions are probably corrupt. Hime's version evidently differs somewhat from the one which I have used (*Artis Auriferae*, loc. cit), but the difference does not appear in the anagram.

[4] R is standard Mediaeval shorthand for *recipe* (take, imperative) and has survived in the *R* which physicians put at the head of their prescriptions.

[5] This significant passage occurs *with the same numbers* in the English translation of 1659, "Faithfully translated out of Dr. Dee's own copy, by *T. M.*" Dr. Dee's copy was printed at Hamburg in 1618.

The history of black powder composition is summarized briefly in the following table.

	Saltpeter per cent	*Charcoal* per cent	*Sulphur* per cent
1350. Arderne (laboratory recipe)	66.6	22.2	11.1
1560. Whitehorne	50.0	33.3	16.6
1560. Bruxelles studies	75.0	15.62	9.38
1635. British government contract	75.0	12.50	12.50
1781. Bishop Watson	75.0	15.0	10.0
1923. U. S. Army	74.0	15.6	10.4

For nearly four centuries the composition of black powder has changed but little. Improvements have been in the technology of manufacture. The formula which was current in Queen Elizabeth's day is still the standard formula in many European countries for black powder for military purposes. Smokeless powder has displaced black powder as a propellant for artillery use and has largely displaced it for sporting purposes; but, where smoke is no objection, for use in producing a quick hot flame and in communicating fire, black powder is not likely to be superseded.

Bacon closes his letter on the Nullity of Magic with the statement, "Whoever will rewrite this, will have a key which opens and no man shuts: and when he will shut, no man opens." Bacon saw the possibilities in the stuff. The slightest reflection tells us that he did not boast.

Gun Recoil and Recoil Systems

By

ALFRED G. ZIMERMANN, U. S. N.

Historical

THE end of the Civil War seemed to stimulate the pens of naval-military correspondents and commentators to a remarkable degree. Perhaps this was a natural result of the comparative suppression of the previous four years, although censorship as efficacious as we know it today did not exist. There followed widespread discussions of the ideas gleaned from actual war experience—particularly concerning material—and numerous solutions for avoiding disaster in the future were advanced.

Soon the spirited articles on whether cast guns were equal or superior to built-up guns, whether breech-loading guns were better for all purposes of warfare than muzzle loading and whether guns should be rifled or not, were succeeded by equally animated discussions on the best system of building up guns; the weight, shape and charges of projectiles; and the shape and character of twist of the rifling. In the midst of all the current writings of the day, the equally important but considerably less dramatic gun mount received but scant attention. It was rarely that any comment on gun carriages was published with sufficient detail to permit a reconstruction of the system on which the designer depended for absorbing the recoil of the gun.

Gibbons' Artillerist's Manual, which was used in 1863 as a text-book at West Point, gives what apparently is a complete survey of the methods of absorbing the recoil of guns in the field. In the first place, there was a certain definite ratio between the weight of the carriage and the caliber of the gun. A carriage too light would permit the whole to recoil an excessive length and a carriage so heavy as to be practically immovable would soon be injured by the repeated shock of firing. The main effort, however, was concentrated on "friction, skillfully applied." This by no means resolved itself into any one best method of creating friction. Any number of the following practices were resorted to, either separately or in combination, to attain the desired end:

(a) Decreasing the outside diameter of the carriage wheels, or increasing the diameter of the axle, or both.

(b) Raising the trunnions of the guns above the axletree so that the greater leverage of the gun would force the trail of the gun to hug the ground better.

(c) Placing the trunnions of the gun farther to the rear and at the same time shortening the trail, to accomplish the same purpose.

(d) When restricted space made an even shorter recoil necessary, the artilleryman passed a heavy line between the two upper rims of the carriage wheels, just above the trail. As the carriage recoiled and the wheels turned, the line caused the trail to dig deeper into the ground.

(e) In the case of fixed (barbette and garrison) guns, the carriages slid up an inclined, wooden track.

As to the status of naval mounts, the Navy Bureau of Ordnance report for the year 1864 makes the sweeping statement that our "broadside gun carriages are essentially the same today as in the year 1750." Some slight modifications were mentioned, one of which was "the removal of the rear trucks and substituting a vertical friction piece on the brackets to resist the movement of recoil." A recoil check was devised by Captain Alden and tried on the 9-inch guns of the *Brooklyn* in the Battle of Mobile Bay and was recommended for adoption. This was evidently a friction device also, as the statement is later made that the recoil of pivot guns is easily controlled by compressors. In that year iron gun carriages for broadside guns were first introduced.

Foreign Developments

The *Army and Navy Journal*, in 1868, printed an excellent summary of English progress in gun-carriage design. It appears that the Admiralty assigned the *Excellent* as a gunnery training and experiment ship. A civilian, Mr. Cunningham, had since 1862 experimented with a 110-pdr. Armstrong gun having a compressor in which he introduced the principle of large friction surfaces to check the gun's recoil in lieu of the old-fashioned claw and riband arrangement. There was great rivalry between him and Captain Scott in the improvement on gun carriages.

The publications of those days were enlivened by charges that our English cousins were benefitting by our ingenuity during the war and failing to give us due credit. For instance, *Frank Leslie's Weekly*, of 1872, publishes glowing accounts of Captain Scott's gun carriage on H. M. S. *Glatton*, where there was a reversion from the new style hydraulic recoil buffers to the old principle of taking up the whole force of the recoil by bow compressors. The *Army*

and Navy Journal promptly charged that not only was this "new" carriage a plagarism of Eriesson's ideas as incorporated in the original *Monitor*, but that the development on the other side of the water was caused by the appropriation of a set of Eriesson's detailed plans.

Again, *Naval Science*, a British quarterly, reviewed in 1874 the progress made in hydraulic means of taking up recoil, which drew forth the assertion on our side that Captain J. B. Eads had taken up the recoil of guns on steam or air cylinders in several of the western ironclads during the Civil War, and that his pioneer work had been ignored.

The Confederates used an ingeneous scheme in their batteries along the Red River which was again revived by Colonel Houston in 1868. Excessive recoil was prevented by the carriage dragging a counterpoise, which was so constructed that the carriage had momentum enough left to retreat around a curved track out of the gun port and behind the traverse. Here the personnel could reload in safety, and run the gun into position again when ready to fire.

The British made extensive experiments with this curved track idea in 1875, and apparently with the purpose of forestalling further uncomplimentary remarks, the *Army and Navy Gazette* (English) announced that this was a development of a Chinese system used in the Taku forts. The Chinese had two gun carriages connected by a long stout cable which also wound around a post revolving in a deep socket situated in front of both. One gun carriage was in a position to fire, the other in the rear. When the first gun was fired, its recoil to the rear pulled the second gun into position for firing.

Freak Models

There seemed to be no limit to the versatility of inventors in dealing with gun recoil. One apparently got his inspiration from the Fourth of July pinwheel. One gun, loaded, pointed out over the barbette, and underneath it was slung a similar gun, but pointing to the rear, which was the loading position. Both rotated about a common axis midway between them. Upon firing the upper gun, the recoil swung the whole so that the two guns exchanged places. A slight modification of this arrangement made an excellent disappearing gun. The underslung gun was replaced by a counterpoise and, when free, the system held the gun over the parapet. Upon discharge the gun rotated to the rear and down, around its pivot, while the counterpoise moved forward and up. As the gun reached its maximum recoil it was caught by a pawl which held it in its loading position until it was desired to fire again.

The Board on Heavy Ordnance, an annual institution in the seventies, bore the brunt of most of these new ideas. The Henson gun is described as a "breech-loading, breech-recoiling gun in which the backward effort of the powder is exerted upon a heavy mass of metal which recoils, permitting the gun to remain in position."

A straight pneumatic recoil system was also considered. The advantage claimed for this method was that in the beginning the full force of the recoil was allowed free sway, but as it grew weaker the air cylinders were constantly exerting a greater braking effect. One type had two air cylinders placed forward on the carriage instead of in the rear as was customary before. Each cylinder was eight feet long and had a diameter of fourteen inches.

Hydraulic Methods

The idea of taking up the recoil by building up pressures on a piston moving in a cylinder seems, like "Topsy," to have just grown. By 1873 the system was being experimented with generally, but apparently no one was generous enough to concede the original effort to anyone else. Krupp exhibited some 12-inch guns at the Vienna Exposition whose recoil was taken up by hydraulic gear and in the same year (1873) an English 7-pdr. boat gun was successfully tried out which had a buffer cylinder containing oil. At this same time, too, we proved a garrison gun carriage which had a single, long cylinder only partly filled with oil, the piston rod being inserted in the bottom framing of the carriage. The compression of the oil gave the elastic force, it was explained. As usual, however, gravity was depended on to return the gun to battery and rubber buffers received it in its firing position. By 1878 even Spezia (Italy) was trying out hydraulic carriages.

The first mention of glycerin and water found was in connection with Major Moncrieff's 64-pdr. English hydro-pneumatic gun carriage in 1874. One part glycerin and two parts water were the proportions and the experiment was considered a success.

One of our 15-inch Rodman gun carriages of 1883 was described as follows: The recoil cylinder was of cast iron and contained twenty-five gallons of oil. A loose fitting piston perforated by four small holes moved in the cylinder. The gun recoiled about six feet.

The true hydraulic mount, where the gun returned to battery by this means, was found in our 10-inch, 12-inch and 13-inch Mark II mounts installed on the *Massachusetts* class and some monitors of that time. Here a constant pressure of 600 pounds per square inch was kept on the recoil cylinder. Check and spring relief valves took care of conditions during recoil (which was four calibers in length) and the diameter of the piston rod being rather large, the constant pressure acting on the effective area of the piston was sufficient to return the gun to battery. The liquid was simply water, except when freezing weather was anticipated, when the system was drained and a mixture of glycerin and water substituted. The proportions varied with the temperature and as soon as the temperature was normal again the straight water was restored.

By 1899 the spring-return mount seemed to be well established in our naval service, although there were still some 6-inch broadside and 8-inch turret gravity return mounts. By the outbreak of the Great War every gun in our service was of the spring-return type and it is probable that this was the standard type in all foreign services.

Character of Recoil Liquids

None of the records examined went into detail as to the kind of oil used in hydraulic mounts. It might have been unnecessary, for not many varieties of oil were in existence in those days, and perhaps any would do. Even as late as 1899, it was stated that either plain water or oil could be used in naval recoil cylinders in place of the standard glycerin and water mix, in an emergency. The early Army experiments were made with oil and all Army guns today use mineral oil exclusively. There was no difficulty in obtaining it during the late war.

When glycerin and water were first used in recoil cylinders in connection with Major Moncrieff's gun in '73, it was the non-freezing feature that was stressed and apparently governed its selection. It was pointed out in English journals at the time that the observatory at Greenwich had long used an identical non-freezing mix in connection with the operation of their chronographs. Our early works mention the non-freezing characteristic of glycerin mixtures, prescribing the four-to-one ratio at present used, although it is stated that either plain water or oil may be substituted in an emergency. In these days, of course, any substitution without competent instructions would not be thought of.

The glycerin used in our naval recoil systems today is

what is known as grade 2. It may be slightly yellow in color and may contain mineral matter or organic impurities in very small traces only, and is non-acid. Its specific gravity is not less than 1.257 at 60 degrees Fahrenheit, and the percentage of solid matter present is less than two tenths. There is a decided handicap in the use of glycerin for recoil systems and that is, its use in time of war for the manfacture of explosives. This forces up the price as soon as war production starts and not only does the Navy Department have to stand the extra expense, but every gallon of glycerin used takes away from the supply available for explosives.

No figures have been found prior to 1915, when foreign demand must already have had its effect, but during that year we bought glycerin for as low as $2.54½ a gallon. During September 1918 we had to pay $6.13½ a gallon. Today (1923) it is issued at the price of $1.76 a gallon. These figures are eloquent. If it were unavoidable for the Navy to take this financial penalty at the outbreak of hostilities, it could be classed as one of the necessary contingencies of war; but is it unavoidable?

Ingersoll, in his Ordnance and Gunnery, deduces the formula on which the recoil cylinder orifices are calculated and which sets forth the action taking place in the cylinder during recoil. The only characteristic of the liquid which enters into it is its weight (specific gravity). Our designers today use essentially the same formula.

During 1917, the Naval Gun Factory, in collaboration with a prominent industrial research laboratory, attempted to find a cheap substitute for the glycerin and water recoil cylinder solution. Knowing the basis on which recoil calculations are made, they bent their efforts on duplicating the specific gravity of the mixture. Several attempts to produce a satisfactory substitute ended in failure.

A change of officers about this time brought one to the desk who knew nothing about the elements on which the design of recoil cylinders was based, but in visualizing the action which went on during recoil, recognized that the flow of any liquid through restricted orifices was dependent on viscosity. So when an energetic salesman of an oil refining company came looking for business he was promised a large order if he could furnish a mineral oil to the following specifications:

(a) To approximate given viscosities (those of glycerin and water).

(b) To have domestic ingredients not in demand for other war activities.

(c) To have a neutral reaction and be safe to handle and store.

(d) To have a cold test well below 0 degrees Fahrenheit.

In due time a sample arrived, was sent for proof test in a mount and functioned perfectly. It was called Buffer Oil B, and cost 35 cents a gallon. Soon after, recoil cylinders which had contained glycerin and were later filled with buffer oil were found to have a sludge which, when analyzed, showed that this condition was due to the presence of glycerin. No failure at proof ever occurred, however, and great care was later taken to eliminate all traces of glycerin in the cylinders before introducing the oil.

When hostilities ceased, the Bureau of Ordnance ordered the discontinuance of the use of oil and the return to the glycerin and water mix. To complete the record, it should be stated that some buffer oil which had been standing for four years has been recently examined and found to contain some sediment. It was completely clarified, however, by pouring through cheese cloth.

Future Progress

At present the Navy has the 80-20 glycerin-water solution, with spring return as a standard. However, sporadic adventures in design have led to the use of Spica oil (a high-grade lubricant), and hydroline in small quantities. The unhandiness, to say the least, of requiring stations and even ships to have on hand more than one kind of recoil liquid is obvious.

Our recoil springs call for such high stresses with restricted dimensions that few indeed are the firms with temerity enough to bid on proposals for them. When quantity production is imperative, as in time of war, waivers of standard requirements must be granted. From an experience of years in investigating failures of recoil springs in service, it can be stated that the number of failures which cannot be traced to the inability to uniformly maintain a very high standard on a large production basis, are extremely few and far between.

It is considered that recoil springs, even as they are installed today, are more reliable mechanically and need less attention than any pneumatic or pressure system which depend for their efficiency on the integrity of packing or on valves.

If it is desired to have the number of recoil-spring failures approach the vanishing point, it could be done by accepting the handicap of added weight. This is not too high a price for reliability. Therefore the use of springs for new construction whose designed fiber stress is considerably lower than at present would not only vastly increase the margin of safety but enlarge the field of competition among manufacturers and incidentally reduce the price per spring.

In conclusion, the following suggestions are offered:

(a) Discard the glycerin standard with its fluctuating price and adopt an equivalent mineral oil standard for present mounts.

(b) Permit no new designs to creep in using other than the standard liquid.

(c) Retain the spring-return feature for new construction, reducing working spring loads to nearly commercial practice.

As has been shown, many ideas have been advanced in the past for absorbing the energy of recoil and returning the gun to battery The present mount, while not entirely free from imperfections, is a logical development of all these and a reversion to any earlier type would be unfortunate. The suggestions here offered seek to put present types on a still firmer basis.

The Ordnance Districts

THE BOSTON DISTRICT ORDNANCE OFFICE

COL. CHARLES H. TENNEY, *Chief*

IT is the purpose of the writer to give to the readers of ARMY ORDNANCE a brief description of the new Boston District Ordnance Office, with especial reference to its mission in time of peace and in time of war, and a statement of its immediate objectives. The term "new" is used to distinguish the present office from that which existed during the late war and subsequently thereto, closing up the war business.

The district office idea was a war-time development, literally forced upon the department by dire necessity. The purpose of a regular army is to preserve and develop the military art and to defend the nation in time of war, the former being simply a function of the latter.

In supplying the munitions for the army, the Ordnance Department must arrange for their manufacture by the commercial manufacturers of the Nation. If the Ordnance Department performs its function properly in time of peace it will have arranged in advance for the production of the munitions required by the War Mobilization Plans of the General Staff. If it has not done so, then it has failed to perform its duty.

The district office is the connecting link between the commercial manufacturers and the manufacturing service in the Office of the Chief of Ordnance in Washington. The district office is, therefore, the field agency of the Ordnance Department.

With this statement we may pass to the present organization in the Boston district office, with which we are concerned.

This office was opened on July 1, 1922, and the procedure to be followed was in no way specified. The general results to be desired were, of course, known, but the steps necessary to obtain these results were not known, or at best not very well known, since no one had ever taken those steps. We were, therefore, exploring virgin territory. Our initial personnel consisted of one regular ordnance officer, as executive assistant, and one clerk. Our original equipment was known to be incomplete. We were not supplied with complete files of drawings and specifications. The funds available did not permit of this and it is, perhaps, fortunate that we were forced to proceed slowly, as we were able to plan our procedure in accordance with conditions as we found them to exist.

Our first visits to manufacturers quickly demonstrated that, strictly speaking, there is no existing capacity for ordnance production. The tools, fixtures, and layouts that existed during the war are gone, and will not exist again until a new war makes their creation necessary. There are, of course, some few exceptions to this statement, but in general it is true. We found a general interest in our plans and a readily expressed willingness to cooperate with the Department in solving the problems of war-time manufacturing plans. We also found them very willing to get down to "brass tacks" and discuss specific items of our procurement program. When it came to a manufacturing study of any particular item, however, they wanted the whole story. They wanted every drawing, and all specifications, and even gauge drawings, and where possible, such histories of manufacture as the Ordnance Department might have.

Our experience thus far has led us to a rather definite line of procedure. First, we get acquainted with the manufacturer and his plant by a personal visit, by the Chief, his executive assistant, or both. The knowledge that we gain through this visit, together with our knowledge of the requirements enable us to choose those items most nearly within the productive range of the particular concern. Then a conference with the chief executive of that concern generally leads quickly to a definite conclusion upon which production reports and allocations may be based. It is then that we feel justified in securing complete manufacturing information.

Our immediate objective, is to secure an allocation for each of our principal manufacturers, of a portion of the procurement program, and to have each of them accept that allocation and prepare complete manufacturing plans for its production and keep these plans up to date. These plans will of necessity vary rather widely with the various concerns, but in general should consist of:

(a) Complete file of drawings.
(b) Complete file of specifications.
(c) History of previous manufacture (if available.)
(d) Schedule of parts to be manufactured.
(e) Factory route sheets for each component.
(f) Designs of tools, jigs, and fixtures required.
(g) Factory route sheets for assemblies.
(h) Condensed statement of machine tools required to produce the articles according to the schedule of the allocation.
(i) Statement of machine tools required in addition to those on hand in the factory, in number and time, with reference to "D" day. This will be a basis for computing requirements in machine tools, and for determining priorities of delivery.
(j) Condensed statement of small tools, special tools, jigs and fixtures required by months.
(k) List of gauges required, by months, including both process gauges and inspection gauges for the factory forces and the Government inspection staff.
(l) Estimate of personnel required by months.
(m) Estimates for raw material required by months, indicating the source of supply contemplated.
(n) A preliminary draft of a contract covering the production allocated.

Items (a) to (d) inclusive, must obviously be supplied by the Ordnance Department, and form the basis for the manufacturers' study. Reports have been submitted on a number of concerns in this territory and allocations have been secured. The work of completing these plans is now under way.

The program as above outlined sounds rather ambitious, as indeed it is. Perhaps it is an ideal which we will never completely realize, but toward which our plain duty, if not necessity, impels us to strive. Much depends upon the patriotic efforts of the manufacturers themselves, and we believe this factor is to be relied upon.

When our procurement plan is finished, it will be in the head offices of the factories themselves. The actual working out of this plan is a most interesting problem to the Ordnance Department and the manufacturers alike. Its successful accomplishment will require completed standards of manufacturer at all times, and the critical examination of

these drawings and specifications by manufacturers will prove most beneficial to all concerned.

There remains also the problem of the actual war-time organization of the district office. It is necessary to provide officers to have charge of the Government's interests in each manufacturing plant, and also the personnel for inspectors, production men, clerks, storekeepers, etc. The various advisory, supervisory, and control sections of the district office organization must likewise be outlined, based on the work allocated to this district. The reserve officers assigned to this district form the personnel from which these positions will be very largely filled. The matériel problem must first be solved, or at least well outlined, before the personnel problem becomes active. We are, however, taking every opportunity to increase our acquaintance with our reserve officers and are keeping them informed as to our activities and intentions. The matter of specific training is coming up and must be dealt with later.

The peace-time organization of one officer and one clerk is for the time, at least, sufficient for our needs. More assistance may later prove advisable, but its necessity is not as yet apparent.

We feel that we have gotten a good start in the Boston district in the right direction, and hope our present expectations will be justified by future results, some of which are already in sight.

THE NEW YORK DISTRICT

Col. John Ross Delafield, *Chief*

The New York ordnance district has been organized, so far as its principal officers are concerned, for some months, and has been functioning with these officers in the preliminary survey of the district. It is still working over problems of organization and personnel as well as working with the contractors. It is believed that a very efficient organization can be built up. The district chief and the chiefs of the six divisions have been selected, and are as follows:

The district chief is Col. John Ross Delafield, who was graduated from Princeton, A. B. and A. M., and Harvard Law School. He is a business and corporation lawyer in New York City and an officer of several corporations. Colonel Delafield served in the New York militia as regimental commander. He also acted finance manager of the Chicago district ordnance office during the World War, and after the Armistice became chief of the advisory section, Office of the Chief of Ordnance, member of the Ordnance Claims Board, and later chairman of the Board of Contract Adjustment of the War Department. He is an officer of the Reserve Officers Association of the United States. Colonel Delafield was awarded the Distinguished Service Medal.

The executive assistant to the district chief is Capt. H. W. Churchill, Ordnance Department, U. S. A., whose office is located at 39 Whitehall Street, Room 810, Telephone Broad 7509. Educated at Massachusetts Institute of Technology, he was an executive engineer and production manager with the Burke Electric Co., Erie, Pa., before entering the Army soon after the outbreak of the World War. Assigned to the inspection division, he was stationed in the Detroit ordnance district during the war, and has since served on the Salvage Board and the War Department Claims Board in Washington, and is now assigned to the War Planning Section of the Ordnance Department.

Administration Division: Major R. D. Coombs, chief. Major Coombs has served in various engineering capacities in civil life. He was the bridge engineer of the Bangor & Aroostook Railroad and was also structural engineer for electric traction of the Pennsylvania Tunnel & Terminal Railroad. He is now the President of R. D. Coombs & Company, engineers and contractors. He entered the Army in December, 1917, in the Ordnance Department and served until May, 1919. His work was largely in connection with the construction problems of the Nitrate Division. He is a member of the American Society of Civil Engineers and also of the American Railway Engineering Association.

Artillery Division: Major Ross R. Harrison, chief. Major Harrison was graduated from Cornell University in 1908. He then served for several years with the Pennsylvania Steel Company at Steelton, Pa. He then became the manager of sales of the Watson-Stillman Company and resigned this position to enter the Army in November, 1917. Major Harrison served as head of the Cannon Branch of the Procurement Division, Office of the Chief of Ordnance, and received his discharge in May, 1919. He then joined the Manufacturers Iron & Steel Company, of which he is the General Manager.

Ammunition Division: Major F. C. Bull, chief. Major Bull has served since the year 1907 in important positions in the engineering departments of various manufacturing plants. In February, 1918, when he entered the War Department, he was the works manager in charge of all mechanical and electrical equipment, and chief executive of the plant of the La Montagne-Chapman Company. He was assigned to the inspection of artillery ammunition in the New York ordnance district, and served as chief of the artillery ammunition and trench warfare section in that district. For a time after the Armistice, Major Bull acted as commanding officer of the district and served on the district claims board. He received his discharge in November, 1920, and is now with the American Machine and Foundry Company.

Aircraft Armament Division: Lieut. Col. C. C. Goodrich, chief. Colonel Goodrich was graduated from Harvard in 1893, and went with the B. F. Goodrich Company, of Akron, Ohio, of which he became the general superintendent. He was commissioned in the Ordnance Department in the fall of 1917, went abroad as Assistant Chief Purchasing Officer of the Ordnance Department, A. E. F. He received his discharge in March, 1919, but remained in England as agent for the United States Liquidation Commission of the War Department for some months afterwards. He is the secretary and treasurer of the Goodrich-Lockhart Company.

Tank, Tractor, and Trailer Division: Major James E. Fullam, chief. Major Fullam served as an engineer for the New York Telephone Company until July, 1916, when he joined the First New York Cavalry, stationed at McAllen, Texas, and Peekskill, New York. In August, 1917, he entered the Ordnance Department and was in charge of acceptance tests for mobile artillery ammunition at Sandy Hook and then at Aberdeen. Later he became the chief proof officer at the Aberdeen Proving Grounds. After his discharge from the Army in June, 1919, he rejoined the New York Telephone Company as engineer, then served for a time as assistant sales manager of the Bell Telephone Securities Company, and is now with the banking firm of Goldman, Sachs & Company.

Small-Arms Division: Major John J. O'Connell, chief. Major O'Connell has served many years with the Electric Bond and Share Company, of New York, as hydraulic engineer. In 1915 and 1916, he was associated with the British Munitions Board in the study of munition manufacturing facilities in the United States. He entered the Ordnance Department in September, 1917, was assigned to service in the Inspection Division and served first in Canadian plants, then in the Toronto ordnance district, and then as inspection

manager in the Detroit ordnance district and in the Rochester ordnance district. He also served on the claims board of the Rochester district until his discharge in March, 1919, when he reentered the Electric Bond and Share Company as hydraulic engineer.

Coordination Section: Col. James L. Walsh, Ordnance, of the Bankers' Trust Company, chief. Colonel Walsh needs no introduction to the readers of ARMY ORDNANCE, since the association owes much of its existence to him. He was graduated from the United States Military Academy in 1909, and served in the Ordnance Department from 1910 until he was retired from active service in November, 1922. He was commissioned a colonel of the ordnance in the Officers' Reserve Corps in February, 1923. From the declaration of war until December, 1917, he acted as Chief of the Personnel Division of the Ordnance Department. During 1918 he was detailed as a military observer with the allied armies in France, England, Italy, and Austria, later becoming assistant to the Chief of Ordnance. Colonel Walsh was the Secretary of the Army Ordnance Association from January, 1920, until June, 1922. It was he who founded ARMY ORDNANCE, and to his untiring efforts are due much of its success. He was awarded the Distinguished Service Medal, Italian War Cross, and His Majesty's Order of the Cross of St. Maurice and St. Lazarus.

The interviews of the district chief and the executive officer and of chiefs of divisions with various manufacturers show them to be very ready to cooperate, and many of them are now preparing estimates of their probable production of various types of munition in case of a major emergency.

The district office is in the Army Building, 39 Whitehall Street, New York City, to which all communications may be addressed.

THE PHILADELPHIA DISTRICT

MR. J. C. JONES, *Chief*

The organization of the Philadelphia district ordnance office was undertaken during the latter part of last November with Mr. John C. Jones, who was in charge during the later war, reappointed as district chief, and Capt. W. F. Vander Hyden, Ordnance Department, as executive assistant.

During December the office was established, necessary equipment and supplies secured, and careful consideration given to the matter of how to best accomplish the initial task of making an industrial survey of the district.

In this connection a number of former officers, manufacturers and trade associations were consulted, as were also several of the earlier established district offices.

In general, the task has for its purpose the ascertainment of the present production capacity of plants, as determined by their resources, organization, plant facilities, machine and tool equipment, and the coordination of these factors with past performance of these plants in the production of ordnance material; the adaptability of the plant for the manufacture of special articles which the Ordnance Department may particularly require, the buildings or ground available for expansion, the additional facilities required to obtain maximum production, and also the opinion of the management as to the items they could best handle with maximum use of their commercial facilities and experience.

A letter outlining in general the purpose of the work, the information desired and requesting the name of the official to be interviewed is sent to each plant. In all cases a personal visit and inspection of the buildings and equipment is made, and a more or less detailed report compiled containing all information which may be of use to any of the supply departments in determining whether the plant could fill any of their war requirements. Since the first of the year the work of the district office has been confined to visiting plants where past war record or present commercial products indicate that they might be able to manufacture artillery ammunition components. The following is a sample of the report made for each plant visited, which indicates, in general, the type of information being collected at this time:

The A. B. C. Motor Corporation

Office and plant, Philadelphia, Pa.; officers, *W. R. Roberts, president; *J. C. Brown, general manager; T. R. Clarke, superintendent; rating, over a million; allied company, Long Foundry Co., Chestnut Hill, Pa.; commercial product, gray iron casting; four-cylinder gasoline motors, including cast cylinder blocks, cylinder heads, engine bases, flywheels, etc.; purchase rough forgings for crankshafts, connecting rods and countershafts, and also bar stock for bolts, tappets, valves, etc. All of the above items are machined at their plant and the complete motor assembled and tested. Capacity, 275 motors per day; war product, 100,000 75-millimeter cast-iron proof projectiles, cast and machined; 35,000 22-pound fragmentation bombs, 1,500 per day—cast, machined, and assembled; about to start machining 75-millimeter H. E. shell at time of Armistice; equipment, 5 6-tool slab millers for facing engine blocks; 7 milling machines for crank cases and cylinder heads; 6 multiple cylinder drilling machines; 8 cylinder grinding machines; 50 multiple drilling and milling machines; 8 Bullard boring mills for flywheels; 5 gear hobbing machines for timing gears; 4 gear cutters; 14 turret lathes; 9 Norton grinders for tappets and valves; 72 engine lathes, assorted; 26 grinders, assorted; 9 automatic screw machines; 24 screw turret lathes; 160 miscellaneous machines, drills, lathes, boring mills, grinders, etc.; foundry, 4 cupolas (capacity 250 tons per day); 10 furnaces for hardening and annealing castings.

Remarks: The A. B. C. Motor Corporation would be willing to do 100 per cent war work. They are well fitted to furnish gray iron or semisteel castings and to do anything in the machining line on a large basis. They employ about 2,000 men, who are accustomed to precision work, their tolerances being from ¼ to ½ thousandths of an inch. There are about twenty acres of surplus ground and the old foundry, substantially built of brick, 300 by 150 feet, now empty and unused, which would make an excellent machine shop. They would prefer making proof projectiles or cast-iron bombs, as this would provide for the output of their foundry. However, they would undertake the machining of shell bodies, preferably 75-millimeter, and could easily handle 5,000 or 6,000 per day by using one half their present buildings. About 25 per cent of the machinery needed to machine shell would be found among their present equipment and enable them to get started. On account of their wealth of machine equipment they could undertake almost anything in the machining of the smaller articles of ordnance and be able to get a good start with present facilities.

* Interviewed.

THE CHICAGO DISTRICT

MR. E. A. RUSSELL, *Chief*

The Chicago district ordnance office was officially reopened September 1, 1922, when Mr. E. A. Russell accepted reappointment as district chief, and Capt. R. F. Melin arrived as executive assistant. Mr. Russell was chief of

the Chicago district during the war, having been selected by General Tripp early in 1918, and continued on after the Armistice in the settlement of war claims.

A war-time organization for this office, paralleling the Ordnance Office in Washington, is under way, the desire being to perfect the most efficient organization possible, based on the work to be done. The office is now functioning on the hypothesis that the work necessary will be done and that the chief function now is to determine the nature, amount, and order of the work that it may be called upon to do. Upon a satisfactory solution of this fundamental problem, it then is but a simple matter to compare the specifications of the job with the qualifications of the man, and, as agreement is found, that man will be assigned and so informed. This selection of personnel is, of course, progressing, together with the other units of the survey, toward an eventual solution of the whole.

The following representative business men from the important commercial centers of the Chicago district have consented to act with the district chief in the determination of policy and methods of the ordnance problem in the district:

Mr. John J. Mitchell, chairman, Merchants National Bank, formerly a member of the Chicago District Claims Board; Col. Robert P. Lamont, president, American Steel Foundries, formerly Chief of Procurement Division, Ordnance Department, Washington, D. C.; Mr. Alex. Legge, president, International Harvester Co., formerly vice-chairman of the War Industries Board; Brig. Gen. Charles G. Dawes, chairman, Central Trust Co., formerly general purchasing agent for A. E. F., and later director of the budget; Mr. William Butterworth, president, Deere & Co., Moline, Ill., formerly vice-president United States Chamber of Commerce; Mr. A. R. Erskine, president, Studebaker Corporation, South Bend, Ind.; Mr. Frank R. Bacon, president. Cutler-Hammer Manufacturing Co., Milwaukee, Wis., formerly assistant chief, Chicago district ordnance office and later vice-chairman District Claims Board; Mr. W. W. Coleman, president, Bucyrus Co., Milwaukee, Wis., formerly assistant to Chief of Ordnance for Cannon; Mr. George M. George M. Gillette, president, Minneapolis Steel and Machine Co., Minneapolis, Minn.

A considerable amount of preliminary work has already been done on the industrial survey here and has met with most enthusiastic support of all the manufacturers, who very generously have expressed their desire to cooperate in this important work.

THE BRIDGEPORT DISTRICT

COL. B. A. BRANKLIN, *Chief*

The Bridgeport district ordnance office began to function actively about January 11, 1923. The chief assets of this district from an ordnance point of view are the commercial small-arms factories of long experience, whose knowledge and facilities are almost instantly convertible into quantities of ordnance munitions, and also the great copper and brass industries of the Naugatuck Valley, which, during the past war supplied the material for millions of cartridge cases and rotating bands. Automatic machinery and operators, and expert tool and gage makers are also numerous in this district.

Col. Benjamin A. Franklin, of the Strathmore Paper Company, has been appointed chief of the district. He was actively engaged in production of munitions for the Ordnance Department during the past war, both in Washington and in this district, and at the close of the war was charged with the settlement of claims in this district. In recognition of his services during the war, he was awarded the Distinguished Service Medal. The work of this district office at the present time is greatly aided by the fact that Colonel Franklin is intimately acquainted with the resources and possibilities of the various factories through his war experience here and is personally acquainted with most of the manufacturers with whom the office has to deal.

In approaching the problem of an industrial survey of the district, it is planned to draw up a tentative reserve officer organization of the district office patterned after the organization of the Washington Ordnance Office. By allowing the reserve officers to participate actively in this work, the operation of the office will be materially aided, and at the same time the officers will be kept in touch with their probable duties in the event of an emergency.

Lieut. Col. Willis D. Ballard, of Holyoke, Mass., and Lieut. Col. Frederick H. Payne, of Greenfield, Mass., have been assigned to the district office recently, and are cooperating actively with the district chief in effecting the reserve officer organization. Colonel Payne was also active in the Bridgeport district during and after the war.

On February 21, a dinner was held in Springfield, Mass., at which the Assistant Secretary of War and Brig. Gen. W. S. Pierce, from the Office of the Chief of Ordnance, spoke to seventy manufacturers and reserve officers of this district. The definite character of the new district system was discussed, and the cooperation of the makers of possible war matériel was solicited. The interest and approval with which the program of Industrial Preparedness is being met here was shown by the fact that about thirty manufacturers from out of town attended the dinner, in spite of very short notice, conflicting appointments, and severe weather.

A touch of personal interest was added to the event by the presentation of the Distinguished Service Medal to Col. Charles H. Tenney, of Springfield, who is chief of the Boston ordnance district, for his valuable service to the Government in Washington during the past war.

Although the industrial center of this district is in Bridgeport, Conn., as the name of the district implies, the present location of the office, at Springfield Armory, Mass., has the advantage of keeping the district in closer touch with the general ordnance activities, and of making available to the district office the records of the war-time Bridgeport district office, which are on file at the Armory. First Lieut. D. G. McGregor, of the Ordnance Department, has been assigned as executive assistant to the chief of the district.

THE CINCINNATI DISTRICT

MR. C. L. HARRISON, *Chief*

The Cincinnati district office was organized during the fall of last year, and since that time analysis of the task to be accomplished has been given major consideration. Certain plants have been investigated and some interesting and instructive data have been accumulated.

Mr. C. L. Harrison, the district chief, held the same office during the World War and his experience in this capacity in addition to his knowledge of the possibilities of the Cincinnati district are a most valuable asset for the work to be done.

Thus far the organization and personnel of the district office, in addition to Mr. Harrison, are as follows:

Artillery section: Mr. H. W T. Collins, chief. During the war, Mr. Collins was supervisor of inspection of trench warfare material, and also served on the Claims Board of the Cincinnati district. He is now engaged in the manufacturing business in Cincinnati.

Ammunition section: Mr. A. H. Pugh, chief. Mr. Pugh

was connected with the chemicals and explosives division during the war and later served as a member of the staff of the Claims Board in Washington.

Tank, tractor, and trailer section is in charge of Mr. Clifford Greene. Mr. Greene was connected with the Cincinnati district during the war and is now a manufacturer of metal specialties. Capt. Frank Rhame is chief of the small-arms section. Captain Rhame served in an executive capacity in the Inspection Division, and on the Claims Board of the former Cincinnati district. He is now an executive of the Lukenheimer Company, manufacturers of brass specialties.

Lieut. Col. W. A. Dibblee is acting chief of the procurement division. Colonel Dibblee served in the Cincinnati district office during the war and was chief of the inspection division of that district and was also a member of the staff and of the claims board.

The finance section will be in charge of A. M. Cressler, who served in the inspection division during the war and who was also a member of the claims staff and an alternate member of the claims board.

The coordination section will be under the direction of Mr. O. DeGray Vanderbilt, who served as an administrative assistant to the chief of the Cincinnati district during the war and who was one of the original members of the claims board.

Lieut. C. E. Lex, of the Ordnance Department, is executive assistant to the chief of the district.

About April 1, 1923, the district headquarters will be located in the new building of the Southern Railway, Room 716.

The district chief anticipates that the work to be done will go along smoothly and that the utmost cooperation will be given by the manufacturers of the district.

BALTIMORE DISTRICT ORDNANCE OFFICE

MR. HOWARD BRUCE, *District Chief*

The Baltimore district office was opened January 2, 1923. The plan followed has been to proceed cautiously, announcing no policy which events might not make it possible to carry out. As contacts are established with the management of plants in the vicinity known personally to this office, and their reactions obtained, more definite lines of action will be established. No work not justified by results obtained is contemplated.

Thus far the attitude of all manufacturers approached has been not only favorable but enthusiastic. All feel sure as a result of their own experience that months of time and large amounts of money can be saved by the district preparedness plan. They point out that not only is it necessary to make one survey, but that continual contact must be maintained and the plans revised from time to time in accordance with changes in the various plants and with the Ordnance Department requirements.

The feeling is that complete and accurate manufacturing information should be in the hands of all manufacturers to whom allocations are made. A large amount of work should be done along this line, even for plants which had highly successful records during the war. While they have an immense amount of information available at present, this will rapidly dissipate, unless collected in proper form. In many cases it exists in the form of *production* rather than *organization* data. In other cases the reverse is true.

The subject of "Existing Facilities" is most important and interesting. It is becoming more and more evident in this district that "Existing Falicities" for the manufacture of special ordnance material, such as artillery ammunition and guns, either no longer exist or will cease to exist shortly. One firm having $3,000,000 worth of special ammunition machinery states that as soon as its new foundry is completed, the greater part of this machinery will go into the cupola. Special purpose machinery is required for this class of production; no commercial uses for this machinery exist, and by the time it will be required for munition production it would probably be obsolete. To mention a specific instance, the invention of "Stellite" cutting tools has made a great deal of special purpose artillery ammunition manufacturing machinery obsolete already.

It is becoming more and more the opinion of this office, as the work of investigation progresses, that reliance for the possible production of war material should mainly be placed on firms with a record of accomplishment, having strong executive organizations, capable of large expansion and on equipment of precision machine tools for the initial production of gauges, jigs, dies, tools, and fixtures. The production of the latter was found to be one of the low spots during the war, and, as such, limited production to a great extent.

On the other hand, there are "Existing Facilities" for the direct manufacture of some few items of ordnance and, indirectly, for the manufacture of many more, principally contributory, however, such as gauges, jigs, dies, and fixtures. Attention is invited to the fact that the observations made above agree almost exactly with those of Mr. George H. Gillette, of the Minneapolis Steel and Machinery Company.

The study of the production capacity of this district for complete rounds of 75-millimeter high explosive has been completed and forwarded to Washington.

It is thought that the production of this district in other lines was not fully developed during the war, and that other sources will be unearthed from time to time, particularly in the southern part of the district.

Hagerstown, Md., was the first locality to be visited outside of Baltimore. A prominent Hagerstown manufacturer requested a number of other manufacturers to meet at a local hotel, the list of requirements was gone over thoroughly and this resulted in the names of a number of other firms being suggested. The following day these firms were interviewed and their plants inspected. Representatives of eleven firms were interviewed altogether in less than two days' time, and the entire locality very thoroughly covered.

A program has been outlined for the preparation in printed book form of complete manufacturing data on all processes of 75-millimeter H. E. complete round manufacture. The plan is to take the data for each component from whatever manufacturer produced the best results during the war. His process can be modified to suit the needs of individual contractors, but the books will serve as an example of the best practice. There would be a book for each component, as "Fuze Metal Parts," "Shell Forgings," "Shell Machining," etc. These books, to be printed on standard letter-size paper, include reduced size, machine, tool, and gauge drawings, folded inserts of complete shop layouts, and illustrated with numerous photographs for the sake of clearness.

Through its contact with prominent executives and engineers with valuable experience in the design and production of ordnance material during the war, the indications are that this office can be of considerable assistance to the Ordnance Department and to the Ordnance establishments in the vicinity from time to time in the future.

Artillery Division Notes

Schneider Company Artillery Development.—The tendency of post-war artillery development by Schneider & Company has been toward pieces having greater range but retaining the same degree of mobility. In divisional artillery ranges of about 13,500 yards are obtainable with later models of 75-mm. guns, and about 11,000 yards with the 105-mm. howitzer. The carriages permit a maximum elevation of about 40 degrees (so that the maximum range of the piece is obtainable without burying the trail). The recoil mechanism is of the Schneider type for long recoil. The trunnions are located near the breech and a counterweight is located over the breech. The independent line of sight is omitted, and the angle of site is separated from the angle of elevation of the gun in the sighting mechanism. The carriages are provided with a shield so located as to clear the wheels.

The increased range feature is most marked in the mountain artillery, where ranges of about 9,000 yards are reached in a 75-mm. gun, and 105-mm. howitzer, as compared with about 6,000 yards in previous models. Units of this materiel are designed for draft transportation on two wheels as well as pack transportation. The carriages are of the same general type as for divisional carriages, having box trails, axle traverse and the Schneider type of recoil mechanism. The carriage is provided with a shield.

A cranked axle is made use of to obtain greater limits of elevation from a minimum of minus 10 to a plus 40 for the 75-mm. mountain gun. This principle is not applied to the howitzer on account of its lack of stability at low angles of elevation. Ammunition for the howitzer is unfixed to permit use of various zones.

In heavy mobile artillery a 280-mm. howitzer has been developed to have a somewhat less range than the 240-mm. howitzer but to use a 75 per cent heavier projectile and at the same time to be a lighter unit than the 240-mm. howitzer.

Shields for Mobile Artillery.—Use of shields for modern mobile artillery is governed by the use to which the particular

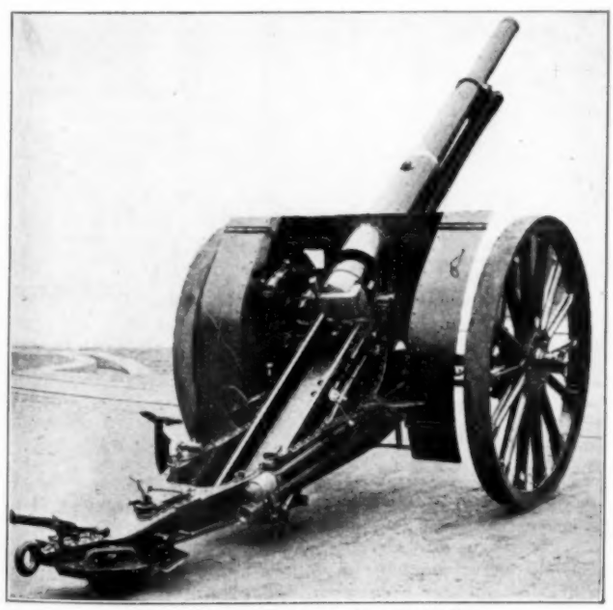

Fig. 1. 75-mm. Gun, Schneider, Model 1919

weapon is put, and by the facilities for transportation with the unit. In cases where the artillery has transportation for only light loads, they can be dispensed with and use made of natural cover as far as possible. This applies to pack artillery where light weight is of the first importance, and shields have been omitted in all our designs. (In some foreign designs, where the unit is arranged for draft transportation as well as pack transportation, shields are used.)

In cases where time permits the carriage to be emplaced, and cover built up, the shield may be omitted from the carriage. In post-war developments of corps and army artillery where this is the case, shields are not provided on the

Fig. 2. 105-mm. Mountain Gun, Schneider, Model 1919

carriage. The 155-mm. G. P. F. Gun Carriage used during the World War had no shield.

In divisional artillery, where the use of the weapon is varied and subject to frequent change of position, a shield has been considered desirable to protect the gun squad. In the first post-war development the 75-mm. Gun, 105-mm. Howitzer Carriage, M. 1920, which has a maximum elevation of 80 degrees, the shield is large and arranged to protect the gun crew at all elevations. An apron is provided as in previous designs. This unit of the split trail type is made heavier by the elaborate shield. In the experimental 75-mm. Gun Carriage, M. 1921 and the 105-mm. Howitzer Carriage, M. 1921, which are axle traverse carriages, and which are much lighter units, a much simpler shield is provided. The shield is limited by the wheels as it moves in traverse. An apron is provided and a top shield which may be lowered for traveling. In the 75-mm. Gun Carriage, M. 1923 (split trail) a straight shield is provided. It has been considered in this unit that the apron can be eliminated as the protection afforded does not warrant the additional complication.

Ammunition Service for Large Caliber Guns.—The arrival at the Aberdeen Proving Ground recently of the first shell and powder cars completes the pilot equipment for ammunition supply of the 16-inch Barbette Carriage, Model 1919. Practice with this materiel is about to begin, in order to establish its suitability for continuous and rapid fire.

The system of ammunition supply and loading as worked out for this carriage is a departure from previous practice, made necessary by the modern type of carriage and the disposition of its magazines. The older type of emplacement, in which the magazines were built into the parapet closely adjoining the carriage and forming a compact unit, is giving way to a newer form. Development of aircraft and bombing has brought about a change in the general aspect of coast defence units.

To lessen the possibility of hits from aircraft, smaller magazines are to be used, and located in extended order at considerable distances from each other and from the carriage. The magazines will be connected to the carriage preferably by a double track, or by a single track with sidings at proper intervals, to permit a continuous flow of ammunition cars toward the carriage without interfering with the prompt return of empty cars to the magazines for reloading. This track connects with the one encircling the carriage, and on which the cars stand or move while discharging their load onto the shell parking and powder transfer tables. These latter are mounted on the rotating parts of the carriage. The discharging of the cars can be accomplished while the gun is being pointed and fired at moving targets. As each car is unloaded it passes on toward the left side of the carriage, where it is shunted to the return track to the magazines. The cars thus

circulate about the rear of the carriage in a clockwise direction, facilitating rapid handling. As the track entirely encircles the carriage, no limitation as to field of fire is imposed. The number of cars contemplated will depend on the proximity of the magazines and the number of carriages to be supplied from them. Probably not less than six of each type of car will be required per carriage. The track system will permit

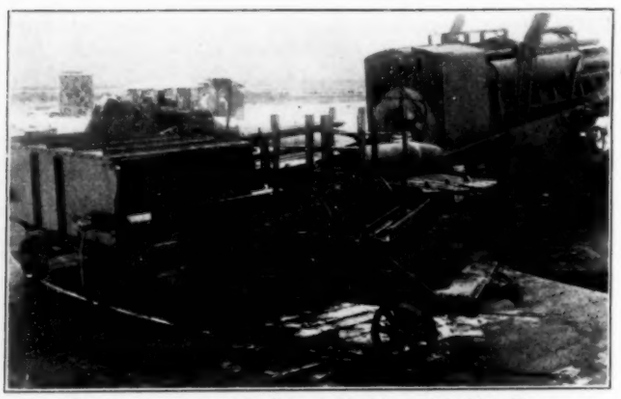

Fig. 3. Powder and Shell Car in Position, Right Side, Rear

any gun of a battery to be served from any one of a series of magazines.

The powder and shell cars are of five-foot wheel base and are identical as to frame and under body. The superstructure differs in each, to facilitate rapid loading and unloading. As built for the 16-inch Barbette Carriage, each car carries three rounds. On the shell car the three projectiles are carried at a height that corresponds with that of the storage platform in the magazines, as well as that of the parking table on the carriage. No lifting of shells is, therefore, necessary. The short transfer in loading and unloading the car is accomplished by rolling.

The upper structure of the powder car consists essentially of a light steel box, the floor of which is composed of a chain conveyor, on which the three charges are carried, and by which they are dumped, as required, on the end of the box, which forms a drop platform when opened. The powder charges, also, are carried at the height of the storage platform in the magazine, and of the transfer table on the carriage. No parking space is provided for powder in the rear of the carriage, this being considered dangerous in the event of a flare-back, and also to avoid exposure to rain, etc., while waiting to be used. Powder charges, therefore, after arriving at the gun, will remain under cover until needed.

Fig. 4. Powder and Shell Car in Position, Left Side, Rear

The parking space for shells, at the carriage, is arranged on the right side of the power rammer, and will accommodate six shells. These rest on rails slightly inclined, so that on operating an escapement the shells are released one at a time to roll onto the rammer, whence they are immediately rammed into the gun.

The powder transfer table is placed on the left side of the rammer, and from it the charges are rolled onto the rammer as soon as the shell has been rammed.

Haulage of cars from magazines to carriage will be provided either by motor trucks fitted with steel tires and small railway type couplers, or by small tractors similarly equipped. Trains made up of three shell and three powder cars will probably best suit the requirements. On arriving at the carriage, the truck will uncouple, leaving the train of cars as near to the parking table as possible, while the truck returns to the magazine with any empty cars that may have accumulated. Circulation of cars about the rear of carriage, during process of unloading, is effected by hand.

The accompanying illustrations show a powder and shell car on the extemporized track around the rear of the carriage, and show their relation to the rammer and parking table. The turntable used in transferring shells will also be noted.

Leveling Mechanism for Anti-aircraft Materiel.—In order to provide for the irregularities of the ground when going into position with the anti-aircraft materiel, it is necessary

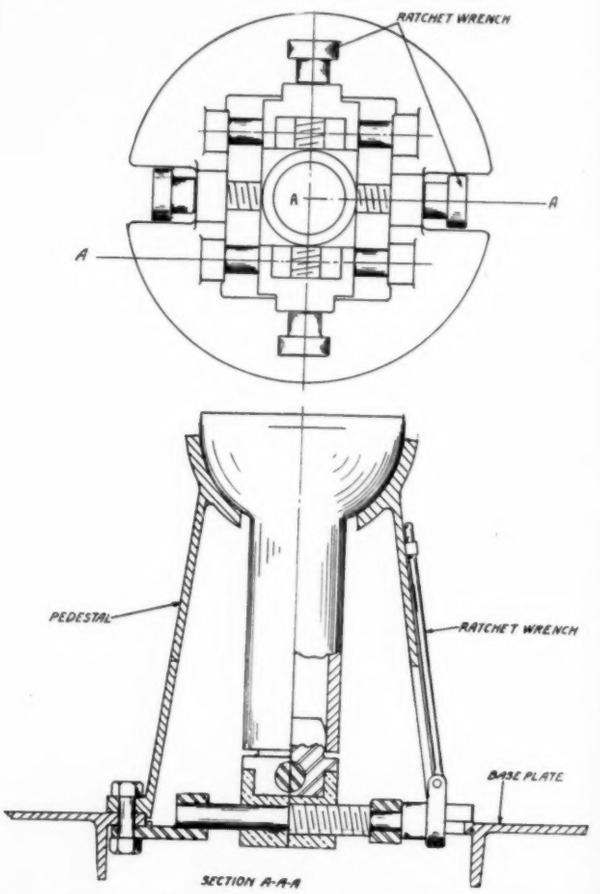

Fig. 5. 3-inch Anti-aircraft Gun Mount, Model 1923, Leveling Mechanism

to provide the mounts with some means for limiting the cradle trunnions to the horizontal plane when the gun is moved in azimuth.

The specifications for the 3-inch A. A. gun mounts, model of 1920 and 1923, and the 4.7-inch A. A. gun mount, M 1920, required that the mount be capable of a leveling movement of five degrees in any direction from the vertical.

The leveling mechanism on the 3-inch and 4.7-inch gun mount, M 1920, consists of a train of gears that actuate the traversing parts relative to the pedestal. The traversing parts are supported by a spherical casing. This casing rests in a spherical seat in the pedestal and by operating the two leveling handwheels on the rotating part of the mount, the gears cause the leveling gear case to travel on slides on the base plate. The movement of the leveling gear case causes the spherical casing to move relative to the pedestal, thereby leveling the upper structure of the mount.

This mechanism was found unsatisfactory, due to the expensive machine work involved, to the excessive time required

and forth against the resistance of two calibrated springs and to operate it, and to the location of the handwheels on the rotating parts, which make it impracticable to label the handwheels with instruction plates to indicate direction for leveling.

The leveling mechanism for the 3-inch A. A. gun mount, M 1923, consists of a screw and nut arrangement as shown in the sketch. The upper structure of the mount rests in a spherical seat in the pedestal and engages the upper nut of the leveling mechanism. The pedestal and leveling mechanism are held to the base plate by the one set of bolts as shown in the sketch. Four ratchet wrenches are furnished with each mount but only two are used at a time. The handles are hinged for convenience in operating. To level the mount the screws are turned by the wrenches driving the nuts—the lower nut being guided by the two cylindrical guides and the upper nut being guided by the lower nut. The lower screw is held by the leveling base plate and the upper screw by the lower nut. This mechanism involves no complicated or expensive machine operations and is rugged, accessible, and direct acting.

Armor Plate Development.—Armor plate development now

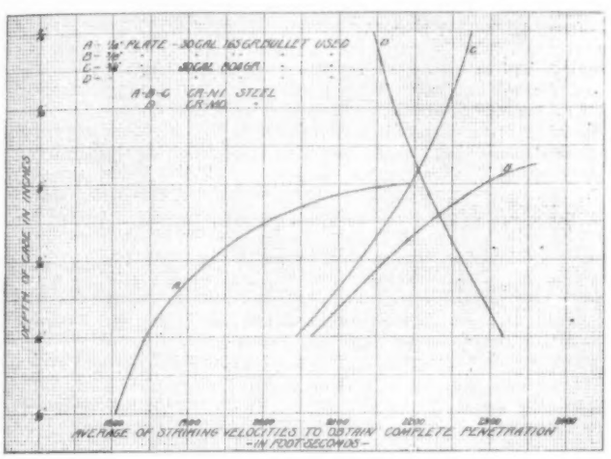

Fig. 5. Average striking Velocities to obtain Complete penetration of Plate

under way was inaugurated for two reasons, the first being the need of securing better plate, which means the obtaining of the highest resistance for any particular thickness. The influence of this factor of the development is quite obvious, as with the improvement of small-arms ammunition, .30 and .50 caliber armor piercing, it is the desire to keep the weight of armor down to a minimum. The second reason that prompted the development consists of the necessity of writing up-to-date specifications involving details of manufacture and test which are better known to manufacturers, in order that there will be less reluctance on the part of the various steel companies to take orders for the manufacture of plate than was evidenced during the late war. In this connection, it is the aim to base specifications, in so far as possible, upon the well-known chemical and physical properties of the steel, thereby minimizing the necessity for prescribing ballistic tests with which the ordinary steel manufacturer is not familiar.

In comparing the thin armor plate developed during the war with the experimental lots of plate manufactured since the war, it has been found difficult to arrive at any basis of comparison due to the lack of uniformity in the method used in the ballistic test of the various plates. This fact has led to the development of a standard method of making tests, wherein the plates are rigidly backed up and striking velocities recorded, and a record kept of each plate tested so that later tests can be compared directly therewith providing the same ammunition is used.

Interesting and valuable data have been obtained from recent tests at Aberdeen Proving Ground of experimental thin armor plate, both case-hardened and homogeneous, of varying chemical compositions and heat-treatments. While it will not be possible at this time to go into much detail in the interpretation of the results obtained to date, a few of the characteristics found will be noted.

By reference to the accompanying figure, the relation between depth of case and the striking velocities necessary to obtain complete penetration are shown. The curves have been determined from averages of plates of the same chemical composition but of varying heat-treatments. It is seen from the curves that for the ¼-inch and ⅜-inch plate, there is a definite increase in resistance with an increase in depth of case, while curves C and D, representing steels of different chemical compositions and heat-treatments, in the one case there is an increase and in the other a decrease in resistance with increase in the depth of case.

In comparing the effectiveness of case-hardened and homogeneous plate, tests conducted to date have demonstrated quite conclusively the superiority of case-hadening in thin plates of less than ½-inch in thickness. For the ¼-inch plate, there is a difference of approximately 500 foot-seconds in striking velocity in favor of the case-hardened plate. This difference decreases in the case of the ⅜-inch plate to approximately 300 foot-seconds, while in the case of the ½-inch plate, the effectiveness of the case-hardened and homogeneous plate is practically the same in respect to resistance to the .30 caliber armor-piercing bullet. These facts tend to prove that the function of the case on the face of the plate serves to break up the bullet core, thus increasing the resistance of the plate to penetration, but as the thickness of homogeneous plate increases, the bullet core is so deformed, due to the increased thickness of plate through which it passes, that the same resistance is obtained as with case-hardening.

The attending difficulties in the case-hardening of plate may restrict its use to the protection of articles where lightness is imperative.

Watertown Arsenal Notes

Some Special Testing Machines at Watertown Arsenal Testing Laboratory.—The Testing Laboratory at Waterton Arsenal, being chiefly interested in ferrous metals, contains examples of all the commoner and more or less standardized testing machines which are used regularly in routine testing. There are, however, machines which, although by no means unique, are of a more uncommon kind, and which are not met with in every routine laboratory. These more unusual machines have been added from time to time during the past few years, and a short account of some of them may be interesting.

Impact testing machines are well represented. The Charpy pendulum impact machine is, of course, to be met with in many laboratories, having become quite popular of later years. The small, or 30 KGM Charpy machine, is the type most commonly used, and at Watertown the smaller machine is in constant routine use. The larger Charpy machine, however, is unusual in that it is the largest of its kind in this country. This machine has a capacity of 2,170 ft. lbs. and has lately been employed in an interesting research on the effect of different temperatures on the impact resistance of a number of different steels. Its operation has given great satisfaction. The test specimens used in the large Charpy machine are of considerable size, 155 x 30 x 30 mm., and although having certain advantages over the small specimen the additional cost of machining is a factor of importance in routine work.

The Fremont and Izod impact machines are well known and may be seen in many laboratories. The Guillery impact test-

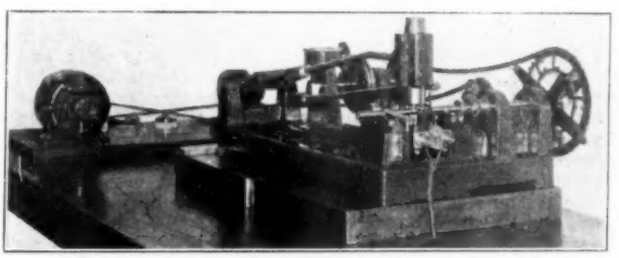

Fig. 1. Stanton Machine

ing machine is not so common, and, although employed to a certain extent on the continent of Europe, it has not been adopted largely in the United States, and it is believed that there are not more than two or three Guillery machines on this side of the Atlantic.

The Guillery machine depends on the energy stored in a heavy revolving disk or flywheel to break a test specimen, the loss of perpheral velocity in breaking the specimen being interpreted in kilogram meters or ft. lbs. which can be read

directly by observing the height of a column of colored water maintained in a glass tube by a small centrifugal pump directly connected to the revolving heavy disk. The Guillery machine

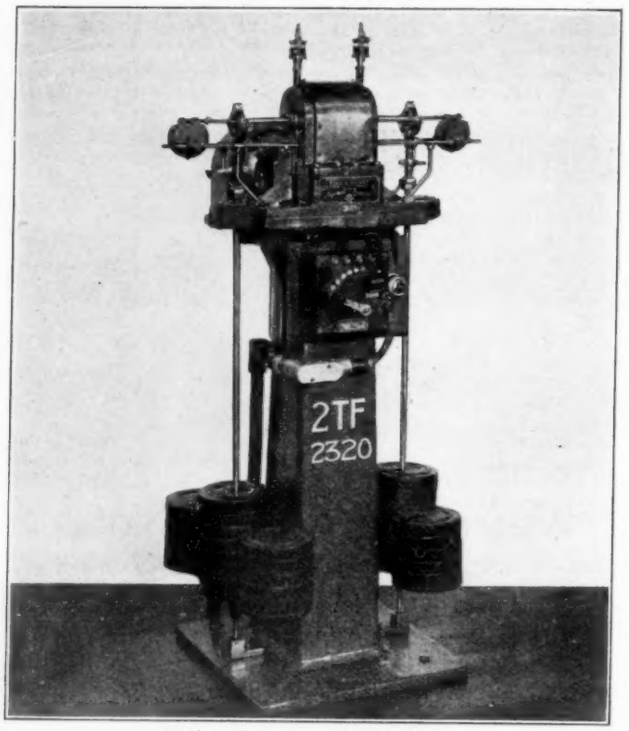

Fig. 2. White-Souther Machine

takes a test specimen exactly similar to the large Charpy transverse specimen.

A carefully conducted series of tests by the celebrated French metallurgists Charpy and Cornu Thenard indicate that this machine is quite comparable in its results to the Charpy pendulum machine. The Guillery machine is adapted only to transverse impact tests, and is not arranged to make tensile impact tests.

Another interesting impact testing machine at Watertown is the "Mouton Universel," designed and made by Amsler & Company of Switzerland. This machine is of the falling hammer type and is on the same principle as the Fremont machine, but the method of determining the excess energy of the hammer after impact with the test specimen is very much better. In the Fremont machine the excess energy is absorbed by springs, the operation of which is not always satisfactory. Some authorities have maintained that the Fremont machine is to be preferred over other types of impact machines, and it certainly has the advantage of using a small and cheaply made specimen. It has been found at the Watertown Laboratory that there is an uncertainty of action of the springs, due to the difficulty of causing the weight to strike quite truly, and furthermore, the method of measuring the depression of the springs introduces unknown errors. In the Amsler "Mouton Universel" the excess energy is transmitted by oil pressure in a positive manner, and actuates a small marker which is thrown upward to an accurately determinable height, thus giving a true and easily obtained measure of the excess energy.

The machine is so designed that it can be adapted to test specimens of wide differences of shapes and sizes, and the energy available and speed of striking are capable of being varied within wide limits.

A small machine for making impact bend tests was built at Watertown Arsenal, and is known as the French Bend Testing Machine. The test made by this machine has been called for in some French gun specifications. The machine consists of a small drop hammer weighing 10 KG. which falls from a constant height of 0.5 meter striking near the end of a plain test specimen held in a vise as a cantilever beam. The angle to which the test bar is bent at each blow is readily obtained from graduations on the vise, the angles and the number of blows the test piece will bear before rupture being the measure of the test. This test is simple and rapid, the test specimen is easy to make and good comparative results are obtained.

During the last few years much research has been undertaken on the endurance of fatigue resisting properties of metals. The object of such tests is to discover the stress limits which a material will withstand an infinite (or indefinite) number of loadings. Although much work has been done in this line and although it is some fifty years since Wohler first endeavored to establish laws relative to the fatigue resisting qualities of certain materials, there is still very little definite knowledge on the subject and the conclusions of Wohler and Bauschinger have had little added to them. Tests of this nature are carried out an repeated impact, repeated stress, and alternating stress and vibratory stress testing machines. At Watertown Arsenal there are a number of such machines.

Of the repeated impact type there are the Stanton and the Matsumura repeated impact testing machines. Both of these machines work on the same principle, differing only in detail. A small hammer falls on the center of a test bar from heights which can be varied. The test bar is revolved through 180 degrees between each blow and is supported at each end as a beam. It is thus struck alternately on each side. The machines stop automatically when the test bar fractures and a counter records the number of blows. The weight of the hammer and its height of fall determine the energy of the blow. Tests are made on plain and notched specimens.

Another repeated impact machine is a Quadruple Hammer Repeated Impact testing machine made by Amsler, and which has four double hammers allowing of four test specimens being tested at once. Each pair of hammers strikes one test bar, one hammer striking on each side. An automatic clutch throws out the pair of hammers acting on a test bar which has broken, and counters record the number of double blows which the bar has received. The above machines are all operated by small individual motors.

Two types of alternating bending stress machines are represented by the White Souther machine and the Farmer machine. In the White Souther machine a test bar is revolved at a high rate of speed while carrying as a cantilever beam a heavy weight at its end. Thus at each revolution, the fibres of the test bar undergo a complete cycle of stress from maximum compression to maximum tension. The Farmer machine

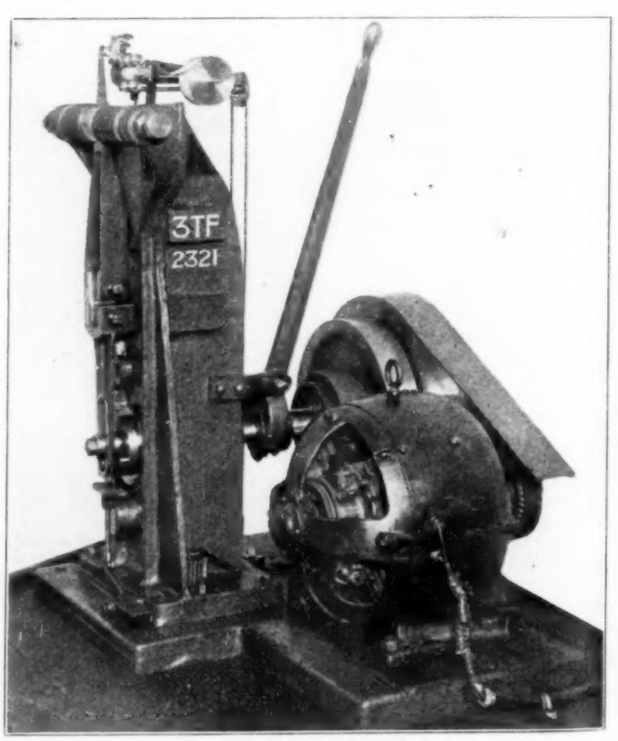

Fig. 3. Upton-Lewis Machine

subjects the test bar to similar stresses but the test bar in this latter machine is placed as a beam supported at each end.

Another machine of an allied type is the Upton-Lewis repeated bend machine. In this a simple test bar is bent back and forth against the resistance of two calibrated springs, and

an autographic recorder indicates the stresses in the bending specimen at each alternation.

The Vibratory machine is one which was originally designed to test material for locomotive boiler stay bolts. The test bar, while under a known direct tensile stress, is vibrated by causing one end to take a circular motion in a plane at right angles to the tensile stress, the other end being held stationary.

The Haigh machine imparts a repeated direct axial stress to a test bar, which can be a standard tensile test bar, or a bar of dimensions as desired. The direct tensile and compressive stresses are obtained by magnets excited by a two-phase generator. In this way very rapid reversals of direct stresses can be obtained, and the effect of speed of reversals can be studied.

The Humphrey notch bend testing machine promises to give interesting information on heat-treated steel. A notched specimen, which can be of the same shape and dimensions as the smaller Charpy transverse notched specimen, is slowly bent to fracture in this machine. An autographic arrangement records the bending moment and the angle of bend at each instant of the test and the work of bending to fracture can thus be computed. Since this machine can operate on similar test specimens, very interesting comparisons can be made with the Charpy machine results, in which the work of rupture by dynamic stress is measured. This machine is small, takes up little space and is easily operated by hand. The autographic recording feature facilitates recording of test results and therefore allows a large number of tests to be made in a short time.

Drilling of Small Bores in Long Cylinders.—The Machine Division received an order which required the drilling of a ⅛-inch diameter hole through 32 inches in length in a ram stem for a hydraulic intensifier used in auto-frettage work. The diameters of the stem were approximately 4 inches on the large end and 2 inches on the small end. It was essential that the hole should be concentric with the exterior diameters.

The operation was performed successfully by using the following method: The 4-inch diameter of the ram stem was held in the chuck in a lathe. The small end was supported in the center rest. The ⅛-inch hole was drilled for a distance of 1 inch in depth, by the use of a small spindle chuck held in the spindle of the tail stock.

One of the most essential points in drilling long holes is that the start of the drilled hole must be absolutely concentric with the outside diameter of the work. The next procedure was the manufacture of a twise drill sufficiently long enough to reach through the entire length of the piece to be drilled. In this case a piece of drill rod ¼-inch diameter, 3 feet in length, was procured.

This drill rod was fluted on one end for a distance of approximately 2 inches in length and machined similar to the commercial ¼-inch twist drill. Directly at the end of the flutes machined in this drill rod the remainder of the drill rod was reduced in diameter .003 of an inch, which allowed the shank of this drill to pass freely through the hole. The fluted end of drill was then tempered.

A clamp-handle device was made that permitted the drill to pass through center of the same and by the turning of the screw collar the drill was held tight and prevented from revolving and sliding back when pressure was applied to the cutting ends of the drill rod.

The stem in the lathe was revolved at approximately 700 revolutions per minute and the long drill was inserted in the already drilled ⅛-inch hole which had been previously drilled to the depth of 1 inch. The wooden hand clamp held the long drill close to the end of the work and prevented the same from revolving. The same was adjusted as depth of cut was increased.

By applying pressure with the hands it was possible to drill

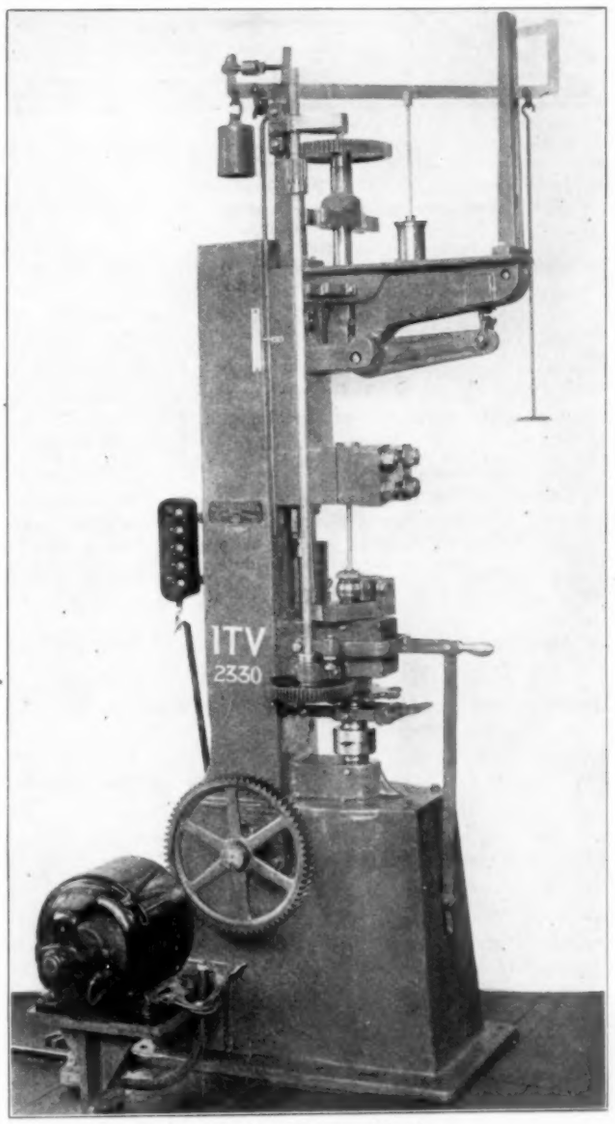

Fig. 4. Olsen Vibratory Machine

1⅞ inches in depth per hour. On the completion of the drilling of the hole through the ram stem it was found that it was off center ¼ inch. The outside diameters were then turned concentric with the drilled hole to complete the job satisfactorily.

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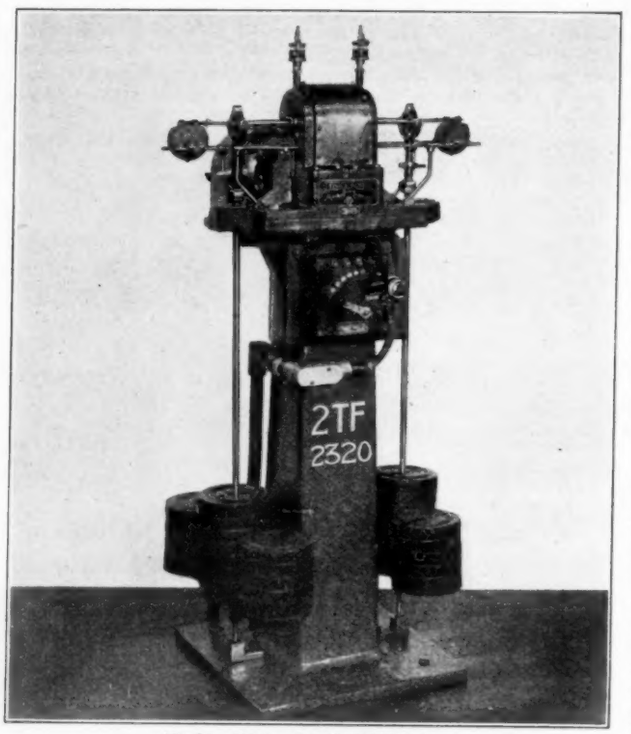

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The machine is so designed that it can be adapted to test specimens of wide differences of shapes and sizes, and the energy available and speed of striking are capable of being varied within wide limits.

A small machine for making impact bend tests was built at Watertown Arsenal, and is known as the French Bend Testing Machine. The test made by this machine has been called for in some French gun specifications. The machine consists of a small drop hammer weighing 10 KG. which falls from a constant height of 0.5 meter striking near the end of a plain test specimen held in a vise as a cantilever beam. The angle to which the test bar is bent at each blow is readily obtained from graduations on the vise, the angles and the number of blows the test piece will bear before rupture being the measure of the test. This test is simple and rapid, the test specimen is easy to make and good comparative results are obtained.

During the last few years much research has been undertaken on the endurance of fatigue resisting properties of metals. The object of such tests is to discover the stress limits which a material will withstand an infinite (or indefinite) number of loadings. Although much work has been done in this line and although it is some fifty years since Wohler first endeavored to establish laws relative to the fatigue resisting qualities of certain materials, there is still very little definite knowledge on the subject and the conclusions of Wohler and Bauschinger have had little added to them. Tests of this nature are carried out an repeated impact, repeated stress, and alternating stress and vibratory stress testing machines. At Watertown Arsenal there are a number of such machines.

Of the repeated impact type there are the Stanton and the Matsumura repeated impact testing machines. Both of these machines work on the same principle, differing only in detail. A small hammer falls on the center of a test bar from heights which can be varied. The test bar is revolved through 180 degrees between each blow and is supported at each end as a beam. It is thus struck alternately on each side. The machines stop automatically when the test bar fractures and a counter records the number of blows. The weight of the hammer and its height of fall determine the energy of the blow. Tests are made on plain and notched specimens.

Another repeated impact machine is a Quadruple Hammer Repeated Impact testing machine made by Amsler, and which has four double hammers allowing of four test specimens being tested at once. Each pair of hammers strikes one test bar, one hammer striking on each side. An automatic clutch throws out the pair of hammers acting on a test bar which has broken, and counters record the number of double blows which the bar has received. The above machines are all operated by small individual motors.

Two types of alternating bending stress machines are represented by the White Souther machine and the Farmer machine. In the White Souther machine a test bar is revolved at a high rate of speed while carrying as a cantilever beam a heavy weight at its end. Thus at each revolution, the fibres of the test bar undergo a complete cycle of stress from maximum compression to maximum tension. The Farmer machine

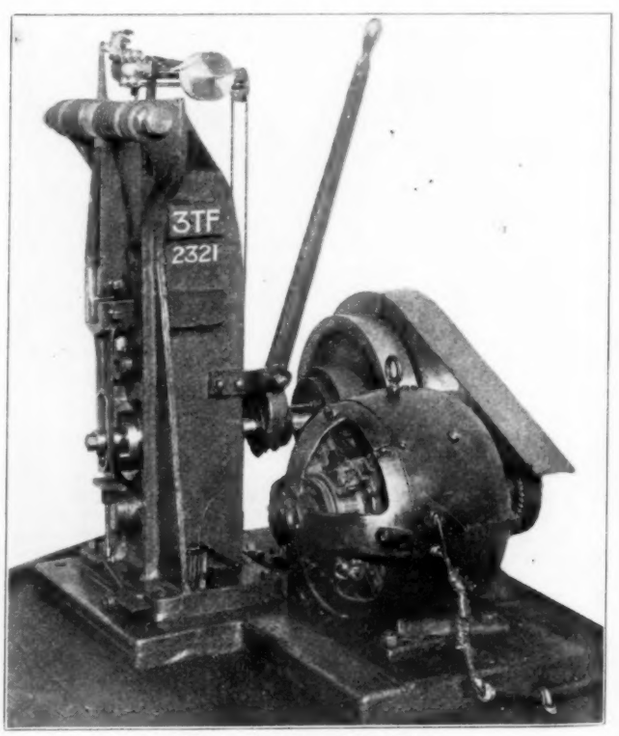

Fig. 3. Upton-Lewis Machine

subjects the test bar to similar stresses but the test bar in this latter machine is placed as a beam supported at each end.

Another machine of an allied type is the Upton-Lewis repeated bend machine. In this a simple test bar is bent back and forth against the resistance of two calibrated springs, and

an autographic recorder indicates the stresses in the bending specimen at each alternation.

The Vibratory machine is one which was originally designed to test material for locomotive boiler stay bolts. The test bar, while under a known direct tensile stress, is vibrated by causing one end to take a circular motion in a plane at right angles to the tensile stress, the other end being held stationary.

The Haigh machine imparts a repeated direct axial stress to a test bar, which can be a standard tensile test bar, or a bar of dimensions as desired. The direct tensile and compressive stresses are obtained by magnets excited by a two-phase generator. In this way very rapid reversals of direct stresses can be obtained, and the effect of speed of reversals can be studied.

The Humphrey notch bend testing machine promises to give interesting information on heat-treated steel. A notched specimen, which can be of the same shape and dimensions as the smaller Charpy transverse notched specimen, is slowly bent to fracture in this machine. An autographic arrangement records the bending moment and the angle of bend at each instant of the test and the work of bending to fracture can thus be computed. Since this machine can operate on similar test specimens, very interesting comparisons can be made with the Charpy machine results, in which the work of rupture by dynamic stress is measured. This machine is small, takes up little space and is easily operated by hand. The autographic recording feature facilitates recording of test results and therefore allows a large number of tests to be made in a short time.

Drilling of Small Bores in Long Cylinders.—The Machine Division received an order which required the drilling of a ⅛-inch diameter hole through 32 inches in length in a ram stem for a hydraulic intensifier used in auto-frettage work. The diameters of the stem were approximately 4 inches on the large end and 2 inches on the small end. It was essential that the hole should be concentric with the exterior diameters.

The operation was performed successfully by using the following method: The 4-inch diameter of the ram stem was held in the chuck in a lathe. The small end was supported in the center rest. The ⅛-inch hole was drilled for a distance of 1 inch in depth, by the use of a small spindle chuck held in the spindle of the tail stock.

One of the most essential points in drilling long holes is that the start of the drilled hole must be absolutely concentric with the outside diameter of the work. The next procedure was the manufacture of a twise drill sufficiently long enough to reach through the entire length of the piece to be drilled. In this case a piece of drill rod ¼-inch diameter, 3 feet in length, was procured.

This drill rod was fluted on one end for a distance of approximately 2 inches in length and machined similar to the commercial ⅛-inch twist drill. Directly at the end of the flutes machined in this drill rod the remainder of the drill rod was reduced in diameter .003 of an inch, which allowed the shank of this drill to pass freely through the hole. The fluted end of drill was then tempered.

A clamp-handle device was made that permitted the drill to pass through center of the same and by the turning of the screw collar the drill was held tight and prevented from revolving and sliding back when pressure was applied to the cutting ends of the drill rod.

The stem in the lathe was revolved at approximately 700 revolutions per minute and the long drill was inserted in the already drilled ⅛-inch hole which had been previously drilled to the depth of 1 inch. The wooden hand clamp held the long drill close to the end of the work and prevented the same from revolving. The same was adjusted as depth of cut was increased.

By applying pressure with the hands it was possible to drill

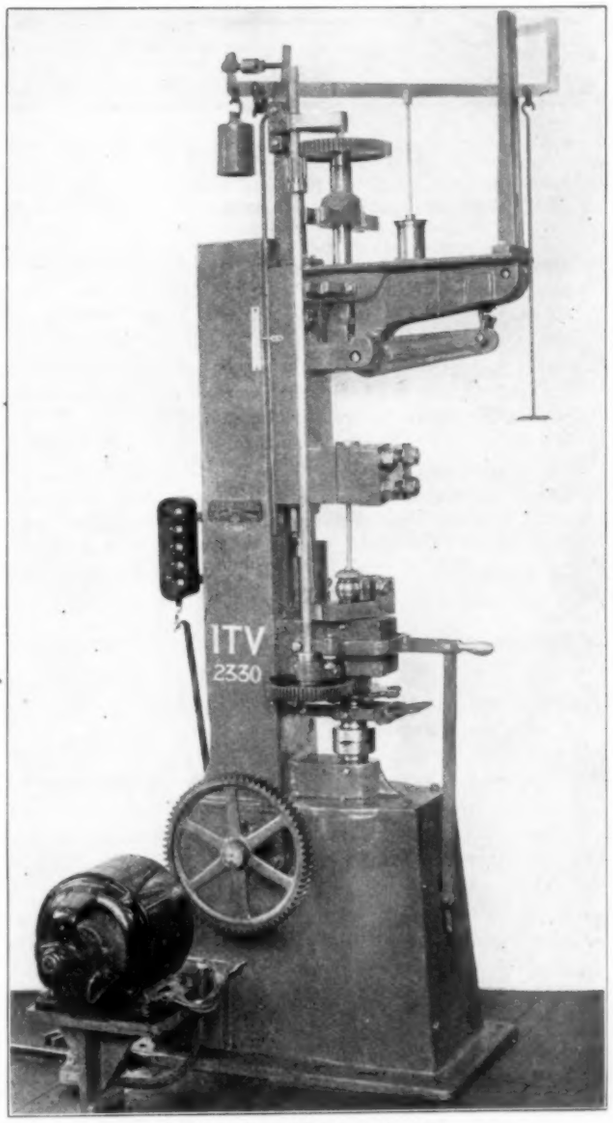

Fig. 4. Olsen Vibratory Machine

1⅞ inches in depth per hour. On the completion of the drilling of the hole through the ram stem it was found that it was off center ¼ inch. The outside diameters were then turned concentric with the drilled hole to complete the job satisfactorily.

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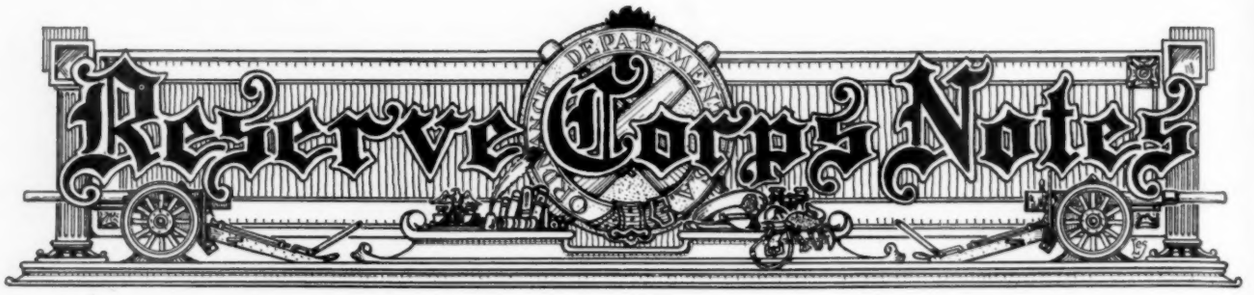

New Ordnance Officers

The following have accepted commissions in the Ordnance Officers Reserve Corps since the last issue of ARMY ORDNANCE:

Major Walter H. Adams, Major David St. P. Gaillard, Major Fritz P. Lindh, Capt. Michael H. Ellison, Capt. John C. Larimer, Capt. James C. Karnes, Capt. Marvin E. Nulsen, Capt. Henry D. Stecher, Capt. James C. Vickery, Capt. Harrison Oaks Parker, First Lieut. Harold G. Burrill, First Lieut. Hillier McG. Burrowes, First Lieut. Edward M. Floreyk, First Lieut. Connie R. Herron, First Lieut. Louis E. H. Huber, First Lieut. Woodford R. Mills, First Lieut. Frank E. Rasbach, First Lieut. Leon C. Reyna, First Lieut. Wilbur W. Runyan, First Lieut. Prosper Russo, Second Lieut. Edson de Castro, Second Lieut. Edgar C. Schroyer, Second Lieut. Chester C. Giddings, Second Lieut. George E. H. Nelson, Second Lieut. Forest F. Lange, Second Lieut. Paul J. Witzell.

Training of Reserve Officers for the Fiscal Year 1924

The following instructions from the Adjutant General of the Army for the training of reserve officers for the fiscal year 1924, are published:

Instructions for Training Reserve Officers of the Army for the Fiscal Year 1924

1. Based upon the budget estimates, the training project will include training for:

a. Three hundred reserve officers for duties under the Assistant Secretary of War in carrying out the project of industrial mobilization plans. Officers will be ordered to active duty as may be directed by the Assistant Secretary of War, provided no officer be called for more than fifteen days.

b. One hundred reserve officers of the general or branch assignment group for fifteen days. The training will be designed to prepare reserve officers, exclusive of officers selected for training under paragraph 1 *a*, for duty in the divisions, bureaus, and branches in an emergency.

c. Four hundred and fifty reserve officers (50 per corps area) for fifteen days' training at corps area headquarters, or elsewhere in the corps area. Corps area commanders will arrange their respective schemes of training, will select the officers to take the course, and will issue the necessary orders to the officers so selected.

d. One thousand eight hundred reserve officers (200 per corps area) for fifteen days for individual training in the duties of their grade and branch of service, by means of assignment for active duty with organizations of the Regular Army, or with the consent of the reserve officers, to National Guard organizations when approved by the State National Guard authorities concerned. Corps area commanders will select the reserve officers, designate the organizations to which they will be assigned, and issue necessary orders and prescribe character of training.

e. Nine hundred reserve officers, not to exceed 100 per corps area, with their own consent, for any period not to exceed forty-five consecutive days, to include preparatory training, for duty at a C. M. T. camp. Corps area commanders will select qualified reserve officers for this duty and issue the necessary orders to those selected. In so far as practicable, not to exceed 50 per cent of the reserve officers so detailed in each corps area shall be National Guard officers holding reserve commissions.

f. (1) Approximately 144 reserve officers (16 per corps area) for the period required to pursue the course of instruction for National Guard and reserve officers at a special service school. By March 15, 1923, corps area commanders will be informed of the inclusive dates of courses for reserve officers, and of any restrictions as to quarters, etc., under which reserve officers will be required to serve. Transportation at Government expense cannot be furnished for families and household goods of reserve officers when called to active duty for this purpose. Each corps area commander will issue the necessary orders to the officers selected. (2) Selection of reserve officers for attendance at special service schools will be made by corps area commanders in such manner as, in their opinion, will produce a well-balanced development of the Organized Reserves, with the object of providing in each reserve regiment a reserve officer qualified to assist the regular officer on duty with the regiment, in the tactical and technical instruction of the regiment. For this purpose, *allotment of funds* to each corps area will be based upon the selection of sixteen officers of the *average grade of major*, but no corps area commander will be restricted in the number, grade, or branch of service of the reserve officers to be selected, provided that the funds finally allotted for the purpose be not exceeded, and provided further that the number of officers ordered to any special service school does not exceed the number specified in the following table:

Infantry	10
Cavalry	3
Field Artillery	6
Coast Artillery	2
Engineers	2
Signal	3
Air Service	6
Field Medical School	2
Field Medical School	1

g. Nine thousand five hundred and eighty-eight reserve officers (1,041 per corps area, 216 Hawaiian Department) for fifteen days at summer camps of instruction to be known as "Organized Reserve Camps."

2. The numbers in items 1 *c*, *d*, *e*, *f*, and *g* are furnished as a general guide and are subject to modification by corps area commanders as may be required by local conditions and funds finally allotted. The limited periods of training under paragraph 1 *a*, *b*, *c*, *d*, *e*, and *g* include time required for travel of each reserve officer from and to his home (par. 132, S. R. 43). Training under items 1 *a*, *b*, *c*, and *d* may be conducted at any time during the fiscal year, subject to the convenience of all concerned.

Rock Island Arsenal Notes

The "Snake" Track.—The demand of the using services for lighter weight track-laying vehicles, possessing higher speeds, greater flexibility and longer life, has prompted designers to spend considerable time and study during the past few years toward the development of new tracks. The conventional type of track, with steel shoes joined by track pins, is unsatisfactory. The stiffness, weight, excessive vibration from road shocks, and the necessity of consuming power in the brakes in steering, condemn this track for anything other

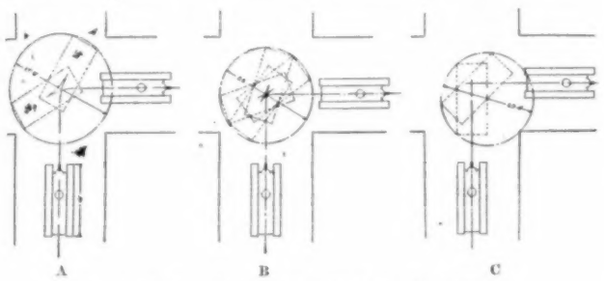

Fig. 1. Radius of turn with and without Snake Track

A. A tank provided with a snake track and a positive turning radius of 20 feet will travel forward 8 feet 8 inches to complete a 30-degree turn. A complete turn of 90 degrees is accomplished in a circle of 27 feet 8 inches, with 3 turns of 30 degrees each, two being forward and one reverse.

B. The same tank will travel forward 5 feet 9 inches to complete an 18-degree turn. A complete turn of 99 degrees is accomplished in a circle of 24 feet, with 5 turns of 18 degrees each, three being forward and two reverse.

C. A tank of the same dimensions provided with conventional steering clutches and brakes can make a turn of 90 degrees in a circle of 23 feet 4 inches diameter, provided perfect pivoting is obtained about center of dead track, which is obtained only under ideal conditions.

than slow-speed vehicles. To meet the requirement of high speed and longer life a track must have a spring suspension of sufficient flexibility to overcome the excessive vibration from travel over hard roads. It must be light in weight and have a high rate of efficiency. It should be adaptable to a means of steering that will reduce to a minimum the horsepower required as well as the stresses and wear in the track, its suspension and the transmission.

The "Snake" type track, which has been developed since the war, is now being adapted to the Army Tractor, Model 1922 E. Consideration is also being given to the use of this track on the 75-mm. Gun Motor Carriage, Model 1924, and the Medium Tank, Model 1924. A worm-controlled differential is used in connection with this track to insure positive turning on a definite radius. The vehicle is mounted on chain suspended bogies which may move laterally, vertically and longitudinally. This combination of track and suspension has many commendable features and gives promise, with sufficient development, of replacing the conventional type tracks on many of the army vehicles. The worm-controlled differential through which positive turning is obtained may be designed to give any desired radius of turning up to the point where skidding of the track makes it impractical. The differential may also be designed to give more than one radius of turning, depending upon the turn desired. This type of control does not require the use of steering clutches and brakes, thereby reducing the power required for steering.

When turning is desired, the application of a brake to one side of the controlled differential causes one track to be driven at a higher rate of speed than the other, giving positive turning on a definite radius. The differential designed for use on the Medium Tank, Model 1924, has two separate sets of brakes, by which the tank may be turned on either a radius of 40 feet or 20 feet, depending upon the nature of turn desired. The 20-foot radius turn, however, requires slight skidding of the tracks over the ground.

The construction of the track shoes with ball joint makes excessive skidding of the track over the surface of the ground in turning impractical. The track shoes would have a tendency to dig themselves into the ground, thereby greatly increasing the resistance to turning. Heavier and more rugged construction would be required in the track shoes in order to withstand the increased stresses resulting from this action. The limiting of the turning radius of the track to approximately 20 feet makes it impossible to pivot the vehicle about the center of the dead track in turning. While this can be accomplished by the conventional type of steering clutch and brake control in our present standard vehicles, the advantages to be gained therefrom are questionable.

Three types of turns through an angle of 90 degrees are shown in the accompanying figures. Figures 1 and 2 show the possibilities of turning within comparatively small circles, considering the length of the track, with practically no skidding, the track being laid down on top of the ground in the arc of a circle. Figure 3 shows the minimum radius of turn to be obtained by the same vehicle, using the conventional steering clutch and brake, the track skidding throughout the complete turn.

The "Snake" track, by adapting itself to the unevenness of the ground surface, gives a better contact, reduces the unit pressure, and relieves the suspension from concentrated loads over rough ground. Continuous running at higher speeds is obtainable because the additional amount of power required for steering is not sufficient to materially reduce the speed of the vehicle.

While many points of favor may appear in this track over the conventional type, a thorough test alone can show the desirability of its adoption for certain types of vehicles.

Its installation on an army tractor weighing 20 tons, a tank weighing 15 tons, and a gun mount weighing 5 tons, each varying somewhat in the details of the track, its suspension

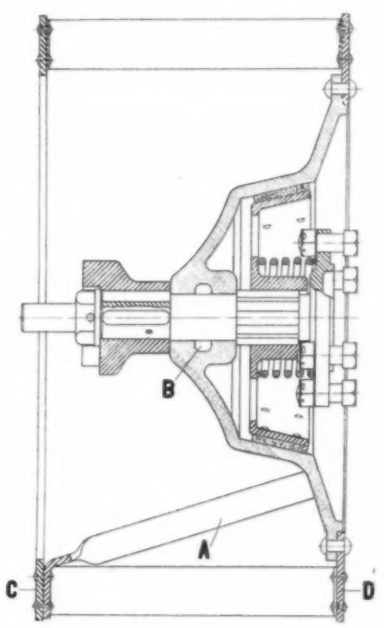

Fig. 2. Modified Fan

and the controlled differential, will give an opportunity to study its action over a wide range of conditions.

Recent Modifications in Army Tractor, Model 1920.—It was recently necessary to disassemble the Army Tractor, Model 1920, in order to replace a connecting rod in the engine and replace some bearings which had frozen in the transmission. During shop tests of this vehicle, considerable trouble had been experienced with the fan, clutch, clutch brake and vacuum system, and it was considered advisable at this time to correct

these troubles as far as possible in order that the corrective features might be tried out prior to being manufactured for and installed in Army Tractor, Model 1922 E.

Modified Sirocco Fan: In the original design of the Army Tractor, cooling of the water was obtained by means of a Sirocco fan forcing air through the radiator. The fan was originally mounted on and keyed to a stub shaft bolted direct to the engine crankshaft, thereby transmitting direct to the fan the acceleration and retardation of the engine, as well as the vibrations of the crankshaft. The forward rim of the fan was supported only by the fan blades, which were eleven inches long. Sudden changes in speed of the fan resulted in reversal of stresses in the blades, with the forward rim tending to lead ahead or lag behind the rear rim. Rapid failure of the fan resulted, the fan collapsing after a short run in the shop tests.

The broken fan was replaced by another fan, to which the brace marked A, in Fig. 1, was added so as to maintain the rate of speed of the forward rim C the same as that of the rear rim D. Though this was successful in preventing the failure of the fan, it resulted in continual wear on the keys

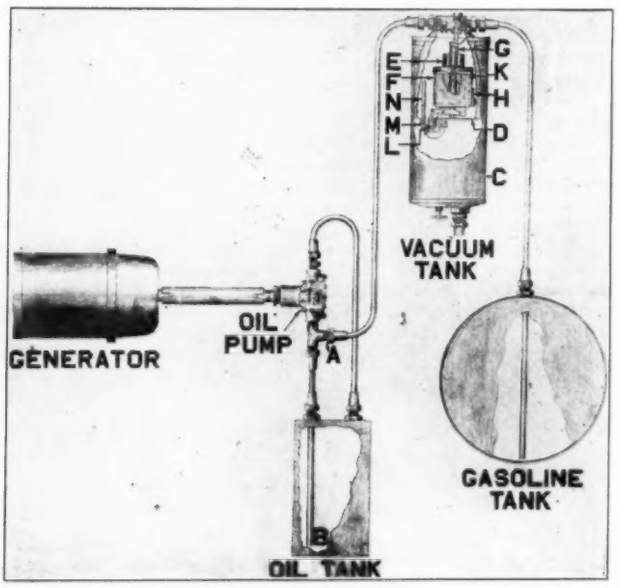

Fig. 3. Vacuum System

and keyways. Thus, after a few miles run the fan developed considerable play on its shaft.

Having determined that approximately twelve horsepower was necessary to drive the fan, studies were made of types of flexible couplings and clutches to ease the stresses transmitted from the engine. The cone clutch shown in Fig. 1, designed to slip at moments of rapid acceleration and retardation, was selected as the most compact design. The inner cone is so splined to the shaft as not to slip when under load. It is faced with ¼-inch raybestos lining, two inches wide, and is held in contact by a helical spring of sufficient capacity to allow automatic adjustment for wear. The space marked B, Fig. 1, will be filled with graphite during assembly to lubricate the bearing surface when slipping occurs.

Vacuum System: The vacuum system originally placed in this tractor depends upon vacuum obtained from the intake manifold. The vacuum decreases in direct proportion to the opening of the butterfly valve, causing the vacuum tank to become exhausted when running with throttle wide open. To obviate this fault an attempt has been made to obtain a vacuum system giving a constant vacuum, or a vacuum increasing directly with the speed of the engine, by using the "Oil-Vac" vacuum system manufactured by Byrne-Kingston & Co., Kokomo, Ind.

The system, with its components, is shown in Fig. 3. The blades in the vane oil pump are held separated and against the housing by helical springs when rotating at low speeds and by centrifugal action when the speed is increased, thus maintaining an excellent seal. A tee, having a small orifice A, is placed in the oil intake line. When pumping oil from the inlet line a vacuum is created in the line attached at A, which varies directly with the lift required to raise the oil from its level to the pump, or as the orifice into the oil-inlet pipe at B is made smaller. Thus, it is possible with a constant speed of rotation of the pump to obtain a desired vacuum either by increasing the lift or decreasing the orifice, or a combination of both. In practice it is obtained chiefly by diminishing the orifice, and it is practical to obtain the desired vacuum by decreasing the orifice even where a gravity head of oil exists.

The vacuum tank consists of a tank proper (C), from which gasoline flows by gravity to the engine, and of a sealed tank (D) placed in the top of the main tank (C). The ingenious mechanism for utilization of the vacuum from the oil pump is placed in tank D. In operation the vacuum draws fuel into the top of the sealed tank D, diverting it by a baffle plate into the cup E, where the gasoline forms an air seal for the top of the inverted cup F. In order that a proper seal may be effected and the gasoline may rise to the same level in the standpipe G as the level in the cup E, an air passage is provided from the inside of cup F down and out below as shown at H, so that after the cup E has been filled the gasoline overflowing into the bottom of the tank and rising, seals H and continues to a predetermined height, at which point the buoyancy of the cork float K overcomes the added downward pressure caused by the air compressed under the gasoline seal in the top of cup E, breaking the seal and by lever action forcing the small pin L downward, breaking the vacuum in tank D. As soon as the vacuum seal in tank D is broken the valve M is opened, due to the action caused by the buoyancy of the float, allowing the gasoline to pass to tank C, air from C to D escaping through the tube N. The storage of pressure in cup F effected by the air seal provided by the cup E, when broken gives an impetus to the pin L similar to that of an impulse starter in a magneto, making positive the breaking of the vacuum seal in tank D. As the gasoline flows out and its level falls to a predetermined height the cork float causes the closing of valve M. During the use of the gasoline from the lower tank air is drawn in around the circumference of tank D, clearance being left in the assembly for that purpose. During the time the gasoline is passing from tank D to tank C, the constant vacuum from the oil pump is satisfied by the air passing from C to D through N.

This system, in contrast to one in which the vacuum is obtained from the intake manifold of the engine where the resultant vacuum decreases in direct proportion with the opening of the butterfly valve, maintains a constant vacuum at constant engine speeds and an increasing vacuum as the speed of the engine is increased. Thus, by so designing the orifice A as to provide the vacuum desired when traveling at the lowest rate of speed for which the engine is designed, we are sure to have a sufficient vacuum as we increase the speed of the engine.

Some question has been raised as to whether the location of the vacuum intake in tank D, directly over the fuel supply, may not tend to cause a certain amount of fuel vapor to be carried down the vacuum line into the oil pump and into the oil supply of the engine. Whether this occurs or not, and if to a degree greater than it is customary to expect from the leakage from the cylinders to the crank case, will be determined in a test to be made on this system by pumping the oil from the vented oil tank and returning it direct from the pump without going through the engine system as shown in Fig. 3. After the test is completed the amount of gasoline drawn into the oil supply will be determined by distillation.

The assembly of the tractor having been sufficiently completed to begin the "running in" of the vehicle without the track, a vacuum of sixteen inches of mercury has been obtained with the motor running at 1200 r.p.m.

Master Clutch: The master clutch used in Army Tractor, Model 1920, which was originally designed for the Medium "A" Tank, where it has functioned very satisfactorily, is of the multiple plate type. Since installation in the Army Tractor, however, continual trouble has been experienced with the clutch due to slipping of the plates, heating, and resultant warping and distortion of these members. When traveling in the higher speeds and attempting to pull slight grades the slippage is especially bad, and several times resulted in freezing the clutch.

The first remedy attempted was the substitution of phosphorous lead bronze for the raybestos lining of the friction

plates. This seemed an improvement, but did not solve the problem.

During a recent disassembly of the tractor it was deemed advisable to go into the problem more thoroughly, and the clutch and clutch brake as shown in Fig. 2 were designed and installed. An attempt has been made to relieve the slipping by substituting for the present plates alternate steel and bronze plates, the latter receiving the drive from the engine and transmitting same direct through friction to the steel plates, which transmit the power to the cardan shaft. The steel plates have radial saw-cuts in from their external diameter to permit of the contraction and expansion resulting from the frictional heat, without warping of the plates. These plates will now be made of spring steel, using a small portion cut and bent out to form a spring to separate the plates when not under load. The use of the all-bronze plates to take the load from the engine will materially aid in obtaining adequate radiation of heat, transmitting same to the outer shell of the clutch and thence to the air. In addition, the substitution of the five steel plates A and six bronze plates C for the old plates has resulted in the obtaining of ten friction surfaces. The need of adjustment, which was necessitated by the wear on the raybestos lining, was considerably improved by the introduction of bronze plates. However, to make the clutch self-adjusting to a reasonable degree it was necessary to introduce some means of obtaining a constant load as wear on the plates progressed. This is obtained as shown by Section B-B. The plunger D presses on ring member E, transmitting the pressure through springs F ring member G, which

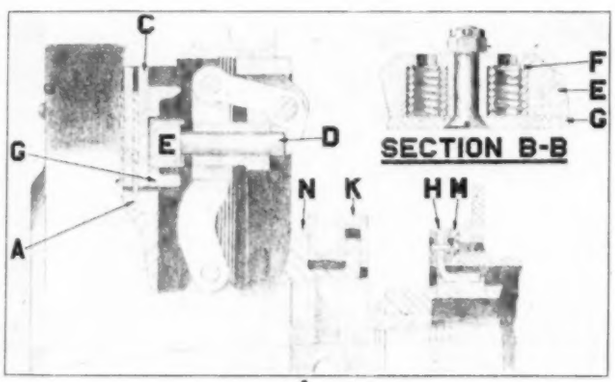

Fig. 4. Master Clutch

transmits the pressure directly to the plate. When the clutch is first assembled, to get the toggle in a neutral position it is necessary to compress springs F, and, later, as wear takes place in the plates, these springs will maintain ring member G in contact, maintaining proper pressure on the clutch plates. Three sets of springs F are placed 120 degrees apart between rings E and G.

During the shop tests the clutch brake originally designed for this vehicle failed to function properly. As a solution a clutch brake of a multiple disc type has been designed. The member H is lined on both sides with raybestos brake lining and keyed to the cardan shaft. When the clutch is disengaged the shifting collar K is pressed against the raybestos lining on one side of H, forcing the lining on the other side against steel plate M, thus securing an effective clutch brake, and without appreciable wear on shifter N. Lubrication of collar K on shifter N is secured by introducing grease through an Alemite connection, with a Titeflex tube running up the inside of the engine compartment and permitting easy acceses for greasing. The preliminary tests since reassembly of this vehicle indicate a big improvement in the functioning of the clutch and satisfactory working of the clutch brake.

Storage Problems.—The following is given as an illustration of the difficulties and unexpected sources of expense to which the Ordnance Department is put in the maintenance of materiel in storage and which is presumably in first class condition.

An inspection in the latter part of 1922 of 155-mm. howitzers in storage at Rock Island Arsenal indicated that the materiel, some of which had been repaired and placed in storage in the latter part of 1920 when funds for this purpose were being exhausted, was in a condition which indicated that thorough cleaning and reconditioning was necessary. One hundred of these 155-mm. howitzers were ordered into the shops to be cleaned, overhauled and reconditioned for issue. The work is now proceeding at a rate of one howitzer per day and at an approximate cost of $75 per howitzer.

In the disassembly of the guns for inspection, certain points were observed which are of considerable interest. It was found that as there were no drain holes provided for draining the cradle, water had collected and, in some cases, was rusting the materiel. It was necessary, therefore, to drill holes beneath the trunnion bracket and at the rear end of the cradle. The same condition was found in the front transom where it was necessary to provide a hole for draining. When the carriages were disassembled it was noted in most cases that considerable rusting had taken place in the brake shaft and on the central part of the axle. Also, at other places where inclosed shafts had been greased, the material was rusting. The question has arisen as to whether it is not better to store the axles and similar material separately from the carriages to which they pertain, so that their condition may be better observed, and the tendency to rust might be somewhat reduced. On nearly all carriages the trunnions had rusted near the bottom. The great weight of the material apparently squeezed grease and oil from this surface. It is possible that such a condition may be stopped by raising the gun slightly off of the trunnion while in storage.

Many of the howitzers in question were new and had never been in use. The front band key, which is provided with a thread at one end and which is held in place by a nut screwing on at this end, had most of the threads stripped off. This was apparently due to the fact that an attempt had been made to screw up on these nuts too tight, and the front band key, being tapered, prevented any movement beyond a certain point. It was found that the holes for the cotter pins had not been drilled. If these had been provided there would have been no necessity for screwing up these nuts so tightly. The brake shoes on many carriages were assembled incorrectly, the wide side being on the inside instead of on the outside of the wheel. A number of carriages had the spade shaft bent, as also a number were found with the cradles spread near the rear end. This spreading of cradle is believed to be due to the accidental release of the safety latch at the front end of the cradle, while the gun is elevated. This allows the gun and recuperator to come to the rear until it strikes against the traversing locks, resulting in spreading the cradle at that point. A number of carriages also had the corrected pressure plates incorrect as to figures shown thereon.

The recuperators for the howitzers were removed and inspected separately. In nearly all cases the liquid level gauge on the front was incorrectly set and necessitated a disassembly of the front end of the cylinder and the change of the angle at which the gauge cock is located. In many cases also there were no name plates on the recuperator and it was necessary to add these. The plates showing dimensions of the piston rod and of the piston rod valve were in many cases either not stamped or else stamped incorrectly. It is most essential that the correct diameter valve be issued to correspond with the particular diameter of the piston rod. It was also found in a number of cases that the filling plug hole at the rear end of the recuperator was not properly located, thus making it impossible to fill the recuperator in the field with the equipment provided.

With regard to these recuperators, a very interesting point developed. Some time ago when this materiel had been returned from France, the glycerine and water mixture with which the recuperators were filled, had been emptied into tanks and placed in storage. When it became necessary to use some of this glycerine and water, it was found that in a number of the barrels the mixture had frozen, some at a temperature of 22 degrees F. This condition led to a thorough inspection and analysis of all glycerine and water mixture on hand. Out of twenty-five barrels of this mixture which had been removed from recuperators and which should have tested 50 per cent glycerine, only twenty barrels tested 50 per cent glycerine. The remaining five barrels tested between 15 per cent and 40 per cent glycerine. This test was by actual chemical analysis, as the specific gravity tests showed such extreme high percentages of glycerine as to indicate that they were untrustworthy. The five barrels having the low per cent of glycerine were also found to be highly acid, the other twenty barrels being neutral. These same five barrels of low per cent glycerine showed a residue when evaporated at 160 degrees C. of 50 per cent, and when the remaining organic salts were burned showed a residue of 18 per cent inorganic salts. The high specific gravity shown in this mixture was evidently due to the impurities in the glycerine. In future work great care should be taken to use only a proper grade and percentage of glycerine and water mixture.

Watervliet Arsenal Notes

Experimental Bombs.—Watervliet Arsenal is engaged in manufacturing a total of 820 fragmentation and demolition bombs for the Ordnance Department, comprising four different types, as follows:

260 fragmentation bombs, Mark II-C, 25 lbs.;
200 demolition bombs, Mark I-B, 100 lbs.;
200 demolition bombs, Mark IV-B, 250 lbs.;
160 demolition bombs, Mark V-B, 550 lbs.

For the purpose of comparing the value of different metals for the bomb bodies of these types of bombs, equal amounts of each type are being made of cast-iron, malleable iron, cast-steel, and semi-steel.

The cut shows the demolition bomb, Mark IV-B, 250 lbs., with adapter, booster-cup bushing and stabilizer assembled. The bomb body is sectionalized to show the interior contour. The other three types differ in size and slightly in contour, but conform in principle to the Mark IV-B shown.

The production of the bomb body castings without special equipment has proved a very difficult and at times discouraging undertaking.

An idea of the tolerances allowed the foundryman on the diameter, length, and wall thickness dimensions may be had when it is considered that the maximum outside diameter of the Mark IV-B shown in cut is 12″.0 with a tolerance of plus or minus 0″.10, and the overall length of the body 27″.343 (27-11/32″) with a tolerance of plus or minus 0″.10, while a tolerance of plus ″.125 and minus ″.05 is allowed on the wall thickness.

It being desired to produce the bomb castings as nearly as possible in accordance with commercial practice, the cast-iron, malleable-iron, and cast-steel bodies were purchased from three different foundries; however, after a thorough canvas of the trade, it was found to be impossible to secure the semi-steel bombs except at the prohibitive cost of from $1.57 to $7.05 per pound.

The manufacture of the semi-steel bomb castings was then undertaken by the Watertown Arsenal, who have practically completed the lot.

The greatest difficulties encountered from the foundryman's point of view has been the contour of the core. The large core area, coupled with the fact that no chaplets are permitted, made it a difficult matter to hold the core concentric within the prescribed tolerances for wall thickness.

The cast-iron and malleable-iron demolition bomb bodies were cast in a horizontal position, the pattern being halved longitudinally. The fragmentation, Mark II-C, bomb bodies were all cast on end. In casting the demolition bomb bodies of cast iron and malleable iron, the pressure of the metal as the mould filled tended to raise the core, making the cope wall thin and the drag side correspondingly thick. This was especially noticeable in the malleable iron, in which the pouring must be quite rapid. The malleable-iron foundrymen finally overcame this difficulty by building up the core onto a 2½-inch steel tube, the ends of the tube being held rigidly in bearings in the flasks. The tube was perforated to permit core gases to pass out through the tube. A great many of the malleable iron castings were lost by cracking, due to the necessity of constructing a rather strong core which greatly resisted the contraction of the cooling metal.

Another difficulty in producing the malleable-iron bomb castings within the prescribed tolerances was the unequal growth of the castings in the annealing ovens. Bombs that were accepted in the hard iron were found to be over the prescribed tolerance after annealing. In the production of the cast steel and semi-steel bomb bodies, the castings were poured in a vertical position, nose end up. This has the advantage of a more balanced pressure on the core in pouring. In pouring the cast steel bomb bodies on end, they were first gated at the top and bottom. The unequal cooling of the sprue and bomb caused the top heads to crack and a considerable number of castings were lost due to the cracks extending down into bomb. Bottom pouring was then tried, but this was accompanied by a considerable wash of sand into the bottom end of the casting. Gating at the middle of the bomb was then adopted with the best results.

Due to the small number of the bombs of each type, subdivided as they are into four different kinds of metal, special foundry equipment at any considerable cost was not deemed advisable. However, if these types of bombs are ever manufactured in large quantities, metal patterns, metal core boxes, and special flask equipment will no doubt greatly improve the quality of product; also, with quantity production permitting special heats of the metal, there will naturally follow an improvement in physical quality and uniformity of the metal in the bombs.

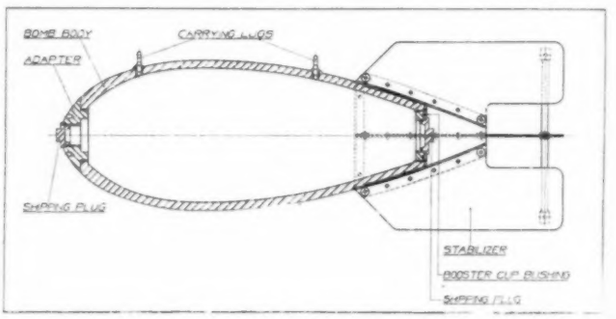

Fig. 1. 250-lb. Demolition Bomb, Mark IV-B

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Recent Patents

Brief Descriptions of Inventions of Interest to Ordnance Engineers

A number of patents have been issued since the first of January, 1923, which are thought to be of special interest to the readers of ARMY ORDNANCE. In giving a résumé of them here they have been divided into three groups: those relating to Ammunition, those connected with Artillery, and those having special relation to Infantry and Aircraft Armament.

Ammunition

BLASTING EXPLOSIVE.—Patent No. 1,440,767, issued to R. M. Cook, and assigned to The Atlas Powder Company is for an explosive intended principally for blasting purposes. The substance consists of a mixture of perchlorates of ammonium and potassium, or the former alone, T. N. T., and a small percentage of an explosive liquid organic nitrate and sodium nitrate. This explosive is claimed to have great stability, to have high resistance to freezing and to be easily handled without injurious effect to personnel, such as headache, etc. Patent No. 1,440,768, issued to R. M. Cook, and assigned to The Atlas Powder Company, is for an explosive such as that just described, the mixtures containing potassium perchlorate without ammonium perchlorate.

IMPREGNATION OF PLANT TISSUES.—Patent No. 1,444,594, issued to W. N. Dehn, relates to a Process for Impregnating Plant Tissues with Ammonium Nitrate. In this process plant meal, sawdust or other similar substances are impregnated with ammonium nitrate by mixing the meal and nitrate, adding water and evaporating.

NEW PRIMER COMPOSITION.—Patent No. 1,443,328, issued to Edmund Herz, is for an article of manufacture, comprising a new explosive which is represented by the chemical formula $C_6H(NO_2)_3O_2Pb$. The inventor claims that this substance, "normal trinitro-resorcinate of lead," is a better primer composition than fulminate of mercury.

GUANIDINE SALTS.—Patent No. 1,441,206, issued to James J. Blair and Joseph M. Braham, of the Fixed Nitrogen Research Laboratory, is for a new method of making guanidine salts, which consists in extracting lime nitrogen with water, filtering the extract, neutralizing the filtered extract with a mineral acid and autoclaving the solution with an ammonium salt.

ARMOR PIERCING PROJECTILE.—Patent No. 1,444,335, issued to John L. Cox, is for an A. P. shell in which the body is reduced in the rear of the band and a detachable base ring is attached to the reduced portion and partly overlaps the band. The purpose of this construction is to allow a shell to right itself in passing through armor without rupture of the shell.

MINE LAUNCHED FROM AIRCRAFT.—Patent No. 1,442,345, issued to Charles L. Kee, for an Aircraft Launched Temporary Floating Mine, discloses a mine, float and parachute. The float has a frame in which the mine is normally held and to which the parachute is attached. The parachute is automatically released when the device lands upon water, the float then upsets and allows the mine to drop out of the frame. A mechanism is provided for regulating the time that the mine will float without sinking to the bottom.

AERIAL FLARE PROJECTILE.—Patent No. 1,442,929, issued to G. E. Elia, for an Aerial Shell, discloses an illuminating shell with a parachute attached thereto by cable, which cable pays out after launching of the shell and operates means for igniting the combustible material in the shell after a given amount of cable is paid out.

MACHINING PROJECTILE BANDS.—Patent No. 1,444,511, issued to A. W. Limont, and assigned to Bridgeport Brass Company, is for a machine for making projectile bands. The device consists of a die having a seat for a flat washer to be drawn into a band, and a punch having a reduced end which engages the washer and upsets it, forcing it into the die; the portion of the punch above the reduced end presents a shoulder which engages the upper rim of the upset band and aids in retaining the band in position on the punch as it is forced through the die.

Artillery

MOBILE GUN.—Patent No. 1,441,102, issued to J. Lund, discloses a gun which may be taken apart or knocked down for transportation without disturbing the recoil mechanism, elevating mechanism and traversing gear. In this structure use is made of a sleigh on the cradle and detachable connections between the sleigh and gun barrel.

AIMING TUBE ADAPTER.—Patent No. 1, 441,837, issued to Dawson & Buckham, for Aiming Tube Adapter for Quick Firing Guns, discloses a practice barrel fitting into a gun tube and having collars which contact the interior of the tube, and a flange at its rear and similar to the flange on the usual shell case for the gun. The barrel is intended for use with a gun provided with a wedge or sliding block. The extractor shaft and usual extractor arms are removed and replaced by an extractor arm and retaining lever.

GUN SIGHT.—Patent No. 1,442,015, issued to E. D. Tillyer, and assigned to American Optical Company, for a Gun Sight, discloses a tube in which is mounted a planatic lens and an object screen with which may be used means for illuminating the screen, the arrangement being such that the object is projected to infinity, as viewed through the lens, thus allowing the sighter to look through the tube with one eye and view the object sighted with the other eye.

BREECH BLOCK FOR MULTIPLE BARREL GUN.—Patent No. 1,443,046, issued to E. Schneider, is for a Closing Device for Guns Having Multiple Barrels. This patent discloses a single breech block of the interrupted screw-thread type adapted to close the breech of all barrels and provided with means for firing the charge in any barrel and extracting the shell from such barrel.

FIRING MECHANISM.—Patent No. 1,443,047, issued to E. Schneider, for a Firing Mechanism for Guns, discloses a disc in which the firing tube is located and to which is pivoted a yieldingly held striker carrier, a coiled spring surrounding the pivot pin allowing the carrier to move longitudinally toward and away from the disc and thus accommodate firing tubes with varying thicknesses of base.

GUN MOUNT ON DOUBLE-TRAILED CARRIAGE.—Patent No. 1,443,048, issued to E. Schneider, for Gun Mount on Double Trailed Carriage, discloses a novel method of mounting the trails and means for balancing the rocking mass on the cradle trunnions in the elevating of the gun. The device comprises cylinders trunnioned to the cradle and having spring-pressed pistons connected by flexible members to a

cross beam fulcrumed at its center in the carriage head; the flexible members passing over guide pulleys carried by the gun pedestal.

DISTANCE CONTROL OF STABILIZED BODIES.—Patent No. 1,442,191, issued to H. Sundhausen and assigned to Fried Krupp Aktiengesellschaft, for Long Distance Control of Stabilized Bodies, discloses a gyroscopically controlled stabilized shaft and electrical connection between this unit and a second gyroscope at a distant station. The second gyroscope is controlled by electromagnets actuated by the current passing through the electrical connection.

FIRE CONTROL MECHANISM FOR ANTI-AIRCRAFT GUNS.—Patent No. 1,445,028, issued to R. V. Morse, and assigned to Morse Instrument Company, Inc., is for Lead Control System for Anti-Aireraft Artillery. The patent discloses a fire control mechanism having a primary sight which generally indicates the point of aim when firing at a moving target, a secondary sight which is trained on the target and means for indicating at the primary sight the point of aim of the secondary sight.

Infantry and Aircraft Armament

AUTOMATIC AND SEMI-AUTOMATIC GUN.—Patent No. 1,441,807, issued to T. F. Horan, for Fire Arm, discloses a gas operated, automatic firearm in which the sear is controlled by a sliding bar which may be manipulated to change the firearm from automatic to semi-automatic.

MACHINE GUN.—Patent No. 1,441,517, issued to Anton Miskunas, for a Machine Gun, discloses a gun in which rotary members or drums feed the cartridges and cartridge belt into the gun. The operation of the drum in feeding the cartridge belt operates the hammer and trigger mechanism. The inventor claims for this gun rapidity of operation without liability of jamming.

MACHINE GUN STANDARD.—Patent No. 1,441,285, issued to J. S. Johnston and V. H. Czegka, for Standard for Machine Guns, discloses a bipod rest provided with yielding means for holding the legs in one of two positions.

GUN LOCK DEVICE.—Patent No. 1,442,864, issued to J. Declaye, for Gun Lock Device for Small Arms, discloses a gun lock having a trigger to which a lever is pivoted, the lever acting on the sear which cocks the striker.

AUTOMATIC FIREARM.—Patent No. 1,442,951, issued to A. C. Ithomitis, for Automatic Firearm, discloses a firearm of the recoil operated type in which the sear is actuated by the trigger through an interposed rotary member in the form of a star wheel.

GUN SIGHT.—Patent No. 1,442,952, issued to Harry H. Jones, for Gun Sight, discloses a gun sight having a novel means for moving the sight vertically and horizontally. The vertical movement of the sight is accomplished by threading a member carrying the peep sight into or out of a tubular member, pivoted to the base, while the horizontal adjustment is accomplished through rotation of a screw which engages the threads on a carriage mounted to slide transversely of the base.

ANTI-AIRCRAFT MACHINE GUN.—Patent No. 1,443,249, issued to P. A. Dupeza, for Anti-Aireraft Machine Gun, discloses a plurality of barrels mounted upon a platform or mount and arranged in groups or units and having means for discharging all the barrels, or the barrels in any group or unit simultaneously, as desired.

AUTOMATIC PISTOL.—Patent No. 1,444,686, issued to A. C. Ithomitis, for Automatic Pistol, discloses an automatic arm having a recoil breech bolt and a sear operated by a specially constructed double jointed lever pivotally connected to the trigger.

MACHINE GUN.—Patent No. 1,444,768, issued to R. L. Wright, for Machine Gun, discloses a plurality of barrels mounted on a horizontal bar and having their front and rear ends connected by rods so that the gun will move in unison, and sights mounted on both rods.

MACHINE GUN.—Patent No. 1,444,849, issued to E. L. A. Paumier, for Machine Gun, discloses means for operating a machine gun or twin machine guns by means of a driven shaft.

AUTOMATIC GUN FOR AIRPLANE USE.—Patent No. 1,444,890, issued to C. G. Swebilius, and assigned to Marlin Fire Arms Corporation, for Automatic Gun, relates to the firing mechanism of an automatic gun, and discloses a striker in the nature of a trigger motor whereby the gun may be operated from an airplane motor through a suitable synchronizing system.

AUTOMATIC GUN.—Patent No. 1,445,583, issued to Samuel G. Green, and assigned to United States Ordnance Company, for Attachment for Gas-Operated Guns, discloses a muzzle gland adapted to be attached to the muzzle of a gas-operated gun for the purpose of choking the gas discharged to cause automatic operation of the gun when firing blank cartridges.

Book Reviews

"BRIQUETTING." By Albert L. Stillman, E. M., M. Sc., New York; Chemical Publishing Company, of Easton, Pa.; XII plus 466 pages, 160 illustrations. Price, $6.00.

The author describes this new book which has just been put on the market as follows:

> "Although thousands of tons of briquettes are manufactured each year from all classes of raw materials, the only text book to date published on the subject is the very comprehensive work—'Handbook of Briquetting,' by Professor G. Franke, translated from the German by Professor F. Lantsberry.
>
> "It is, therefore, thought that the book on the subject, presenting it from the American standpoint, will be of interest.
>
> "It is herewith presented—a product resulting from many years' experience in the art on the part of the author's associates and himself."

This is a book well worthy of the attention of every engineer who has briquetting problems to solve. The first chapter (12 pages) is a discussion of the raw materials with a classification according to the necessity of adding other materials for proper briquetting. The second chapter (71 pages) describes the presses in use for briquetting and is liberally illustrated. Chapter III (12 pages) is given over to a description of the briquetting of steel swarf and turnings; chapter IV (11 pages) to cast-iron borings; and chapter V (21 pages) to non-ferrous metals. Chapter VI (38 pages) is a discussion of binders, with a classification of the various materials and with a paragraph devoted to each giving the characteristics, uses, and limitations of each. Chapter VII (18 pages) is devoted to wood waste. Chapter VIII (27 pages) is devoted to peat and chapter IX (39 pages) to lignite. Chapter X (54 pages) covers the principles of briquetting with binders, coal and combustion of fuel briquettes. Chapter XI (31 pages) is a history of briquetting in the United States and Canada with a list of the most usual causes of failure. Chapter XII (21 pages)

takes up coke and petroleum carbon. Chapter XIII (17 pages) covers flue dust; chapter XIV (76 pages), ores; and chapter XV (25 pages) is devoted to the application of briquetting to chemical engineering in general.

Each chapter is supplied with a bibliography covering the subject which has been treated.

The reviewer's criticism of this book would be the lack of cost data. There is very little on which to base cost estimates. A thorough cost analysis covering the briquetting of some typical material would be a great help to the reader in applying generalities to specific cases.—P. E. H.

SIX PLACE TABLES. 124 pp. McGraw-Hill Book Co., Inc. 1922. Price, $1.25.

An excellent little manual containing a selection of tables of squares, cubes, square roots, cube roots, fifth roots and powers, circumferences and areas of circles, logarithms of numbers, logarithms of trigonometric functions and the natural trigonometric functions. The compilers claim for it "nothing new, radical, or untried." It contains standard information which is of constant reference value to students, instructors, and particularly to engineers. The manner in which the data are compiled and the form and binding of the book commend it especially to those members of the engineering profession whose work includes problems of Ordnance development and application, of kindred industrial activities.—F. S. N.

HANDBOOK OF CHEMICAL ENGINEERING. Vols. I and II. Edited by Donald M. Liddell. McGraw-Hill Book Co., Inc. New York, 1922. Price, $8.00 per set.

This handbook which Mr. Liddell has gotten together with the assistance of some thirty-odd contributors, contains a wealth of valuable material and will, we believe, soon find its place among the necessary working tools of the chemical engineer.

As stated by the editor, the basic idea of this work is to describe the features essential to the majority of our larger chemical industries. Thus basic principles are outlined and their specific applications are discussed.

The work not only contains a most interesting treatment of strictly chemical engineering subjects, but it also includes sections devoted to the smelting of lead, copper, zinc, and iron—which in themselves are trespasses upon the field of metallurgy—but which are treated clearly and with advantage to the general scope of the book.

To the reader who views the data contained in the "Handbook of Chemical Engineering" from the vantage point of its application to the chemistry of Ordnance, the discussions of the various contributors have an especial interest because they are written for the most part on the basis of actual laboratory and shop performance and have the flavor of practical application. The conception of the work is very broad—possibly too broad to suit some of the engineering profession. There are interesting data on rare gases as well as on radio elements which are not generally given in a work of this kind.

Again the plan of treatment is good and the Handbook can be used as such with advantage to all chemical engineers and particularly to those concerned with the chemistry and metallurgy of Ordnance.—L. A. C.

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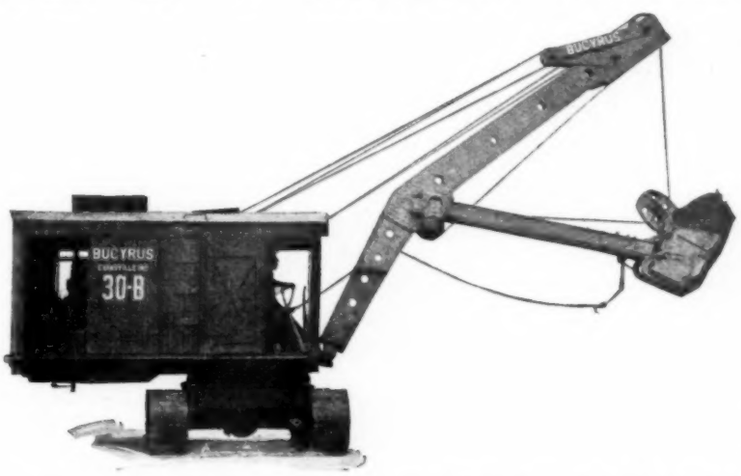

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APRIL

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April 12—*Q. M. Supplies,* Boston, Mass. Auction. For catalog write Q. M. S. O., 1st Avenue & 59th St., Brooklyn, N. Y.

April 17—*Q. M. Supplies,* Philadelphia, Pa. Auction. For catalog write Q. M. S. O., 1st Ave. & 59th St., Brooklyn, N. Y.

April 17—*Buildings and Improvements,* Camp Eustis, Va. Sealed bids. For proposal write C. O., Camp Eustis, Va.

April 19—*Q. M. Supplies,* New Cumberland, Pa. Auction. For catalog write Q. M.S.O., 1st Ave. & 59th St., Brooklyn, N. Y.

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April 24—*Q. M. Supplies,* Camp Jackson, S.C. Auction. For catalog write Q.M.S.O., 1st Ave. & 59th St., Brooklyn, N. Y.

April 27—*Q. M. Supplies,* New Orleans, La. Auction. For catalog write Q. M. S. O., 1st Ave. & 59th St., Brooklyn, N. Y.

MAY

(These sales subject to change.)

May 1—*Q. M. Supplies,* San Antonio, Tex. Auction. For catalog write Q. M. S. O., Fort Sam Houston, San Antonio, Tex.

May 2—*Air Service Supplies,* San Antonio, Tex. Auction. For catalog write M. D. & S. Sect., A. S., Room 2624, Munitions Bldg., Wash., D. C.

The Government reserves the right to reject any or all bids.

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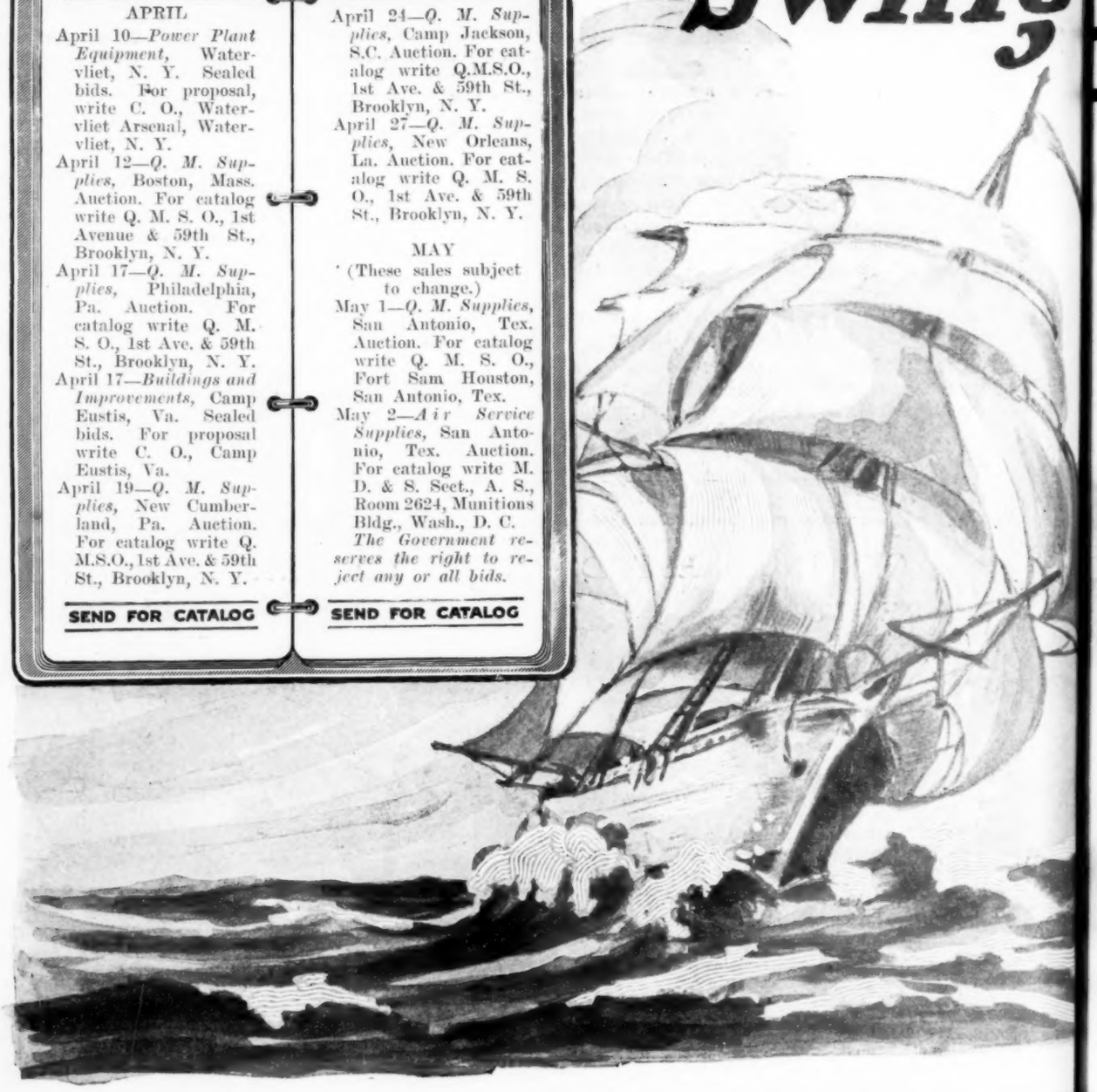

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